DIRECTED THINKING

Books by George Humphrey

THE STORY OF MAN'S MIND

THE WILD BOY OF AVEYRON
(*a translation with Muriel Humphrey*)

THE NATURE OF LEARNING

DIRECTED THINKING

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by George Humphrey

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This book is gratefully dedicated to my dear wife, whose unerring sense of logical form and gift of clear statement have been of great help

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1. INTRODUCTION

FROM where I sit, I can see a young man at the open window opposite. He has been there fifteen, perhaps twenty minutes, hardly moving, an open book on the window sill, a notebook under his elbow. Five minutes ago he scribbled for a few seconds in the notebook; for the rest of the time he seems hardly to have stirred. To the cynic he may appear to be doing nothing. But I know him, and I know that he is doing the most important thing anyone could do, the thing which has raised you and me to power once undreamed of, and may yet reduce us to the dust from which we came.

THINKING HOLDS THE WORLD'S FUTURE IN ITS GRASP

Although man has been thinking for perhaps a million years, it is only during the last generation or so that experimental science has begun to interest itself in thought. Yet striking discoveries have already been made; and although there is much that is still unknown, the general picture begins to be fairly clear. Scientists are slowly reducing thinking to order. The discoveries are of great significance, for thought is incomparably the most impor-

tant thing in the world. By it man has, little by little, raised himself from a squalid creature in a cave, living in perpetual fear of the elements and of his natural enemies, spending his days in a sordid squabble for existence—"Solitary, poor, nasty, brutish." If it were possible to place one of these remote ancestors in a modern city, with heat at his will to warm him and to cook his meals, with light at the turn of a switch and water at the turn of a tap, with complete protection against the weather and no beasts to fear, he would think that the problems of life had been solved and that there was nothing left to do but go out and be happy. If he could be told that thinking had made it all so, that much of this had been started by a curious man who noticed that fragments jumped to a yellow stone when he polished it, and by another who wondered why a frog's legs twitched when he touched them with metal, he would find this difficult to believe.

To the men of the future, men essentially like you and me, we shall seem as naive and as brutish as the cave man seems to us. The timid mother of those future days would snatch her child away from us, even though we are "so fond of children." This would not be because men will know more about the physical world, as indeed they will, but because they will know more about man. For the last five thousand years human beings have been thinking about the world outside, and for a hundred years or so their thinking has been systematic and organized. The result is that we do know many of the answers to the questions that the physical world puts to us.

The next era of progress will concern man himself. When really intensive and systematic thought has been

expended on human beings for a few generations, why they act as they do, why they destroy and persecute and love each other, a revolution so staggering will be effected in our daily living that the difference between us and the cave man will seem almost negligible. All this will be brought about by thinking, which truly holds the world's future in its grasp. It will be thinking like yours and mine, although much of it will be done by unusual men. The last stronghold of fate is human nature, which must be conquered if the race is to survive. Part of the stronghold is *thinking* itself. It is probably the most important part. Somewhere, perhaps, there is a schoolboy who is already beginning to scheme how he can conquer the world. Many boys have dreamed it; Alexander did it, Napoleon and Hitler came close. Somewhere else, another boy is perhaps beginning to scheme how to make it impossible for any man again to conquer the world. Many have dreamed this, but nobody has accomplished it. In some college or other, there may be a young man already turning over in his mind the physical transformation necessary to dissolve the earth in flames. If these particular people do not exist today, it is certain that there do exist young men or young women whose thinking will prodigiously affect the lives of your children and mine. There have always been such people; our generation is no exception. The man who shakes the world must have many qualities. Whatever they are, his thinking is vital to the rest of mankind. We must learn to understand thinking, or it may well destroy us.

YOU AND THE GENIUS DO THE SAME KIND OF THINKING

What then is this thinking, this mover of mountains? Science cannot answer the question but contents itself with the more modest one, "How do people think?" Just as it cannot answer the question, "What is electricity?", but limits itself to the description of how electricity works. To come right down to earth, what is going on when the mother, after long reflection, decides that her child should go away to school, when a girl in the kitchen extinguishes a fire by some quick expedient, or the returning householder thinks out a way of getting into his house when he has left the key inside? These are homely incidents, but they follow the same laws as when some great thinker whom we call a genius finds a way to measure the stars or cure a dreadful disease. You and I have this in common with the great inventors and human benefactors; both we and they think. But they do it better. They are the athletes in the world of mind, who break the record while the rest of us look on from the sidelines, give an occasional cheer, and jump into the car to go home. Our thinking and theirs use the same methods and follow the same laws. If we wish to understand this all-important human activity we can learn to do so by examining the thoughts of the man in the street and the woman in the home. And by understanding our thinking we may learn to improve it.

WHY SCIENCE HAS FOUND IT HARD TO INVESTIGATE THINKING

The scientific investigation of this universal activity presents a uniquely difficult problem, so difficult indeed that numerous good scientists have proclaimed it impossible of solution. Events have shown they were unduly pessimistic, but nevertheless it will be well to glance briefly at some of the difficulties which have to be overcome. To begin with, thought is certainly the most complex thing that happens in the human body. The simpler bodily processes have long been studied by the science of physiology with its attendant sciences of chemistry and physics. The chemist can write across the blackboard a string of letters and figures expressing what happens at a certain stage of digestion. The physiologist will probably require a whole blackboard for the equations describing what happens at the same time in the blood. The psychologist cannot contrive a formula to describe the actions of a child going to school, and still less can any scientist write an equation for the thoughts of youth that "are long, long thoughts." Thus far the immense complexities of human thinking have eluded mathematical description, and whether such description will ultimately be possible, we do not know. But science has gained an understanding of thought which is none the less real because it cannot as yet be expressed in mathematical terms.

In addition to its complexity, thought presents the further difficulty that it is peculiarly elusive under observa-

tion. The physicists have found that ultimate description of an electron in terms of position and velocity is impossible, since, among other things, observation disturbs the electron he is observing. The biologist is often in the same difficulty when he has to kill a living cell in order to find out what is happening in it. The psychologist finds himself in much the same quandary.

Observation interferes with thinking, so that what is observed is often not the natural event. This is equally true whether the thinker is observing his own thought or whether he is reporting what he thinks to someone else. To offer a man a scientific penny for his thoughts disturbs the whole delicate process, but this is exactly what we have to do. To vary the metaphor, we have to pull thought up by the roots to see how it is growing.

The psychologist has adopted various subterfuges to avoid this second difficulty. He has at times examined only simple cases of thinking, which are not so easily disturbed; sometimes, and this method is especially useful with children who often "think out loud," he has used a "one way screen," through which he can hear and see without being seen; he has often relied on memory to report thinking after it has been completed; but memory is notoriously fallible. By piecing together the information obtained in these and other ways he has, however, gained a consistent picture. As in the case of the atom, the difficulty has been more or less surmounted. In fact, the psychologist had partly overcome the difficulty before the physicist knew it existed.

In addition to these two difficulties, there are others. Chief among them is the peculiar and mysterious nature of thought itself. It is the most paradoxical thing in the world.

Thinking involves the activity of a particular person. At the same time it is often, if not always, of universal application! Its course is often erratic but at the same time consistent. Thinking depends on the experience of the thinker but must rise above it. Out of old cloth, suddenly, by the magic of thought, a new garment has appeared! These and many other contradictions all contribute to the difficulty of the problem. It is little wonder that scientists have taken a long time to begin to understand it.

SOME SIMPLE EXAMPLES

By contrast with these scientific difficulties, actual instances of thinking often seem deceptively simple and indeed almost trivial. Two examples of everyday thinking will be given. They deal with homely events and are related in homely language. But do not despise them on that account, for they show—roughly it is true—the pattern by which all human beings think, from the greatest genius to the man in the street. Understand them, if you can, and you will understand the whole mystery.

A scientific acquaintance tells me: "As I was looking for some adhesive tape one zero day I felt a draught. I knew somebody must have left a window open and was afraid the radiators would freeze. Walking down the passage to the sun-room I found that all the windows were apparently closed but that there was snow on one of the inside window ledges. Then I saw that this window was not quite closed. It must have been left open at night and somebody must have tried to close it in the morning.

"I tried to shut it myself, but it would not go. I had a half

thought that there must be snow on the frame. (The windows are in metal frames swinging inwards.) The snow was there all right, more like ice, and I thought, 'The pressure has hardened it. If you compress snow you get ice.' I had fleeting pictures of my physics master at school and of my pocket knife, which was in my other clothes. Then I looked round and saw first a darning needle and then a pair of scissors, and scraped off the snow with the scissors. The window closed easily after that. . . ."

A second example: A friend of mine hears a strange bumping sound in his car. He stops the car, opens the hood, inspects the engine, and is unable to locate the trouble. He starts again on his journey and is relieved to find that the noise has ceased. When he reaches twenty-five miles an hour it begins again, and when he slows up it has disappeared once more. He concludes that the trouble cannot be serious. He pictures in his mind all the parts of the car that could make the noise, but is unable to satisfy himself. After reaching camp he goes to bed without solving the problem, but the next morning as he is cleaning the car he hears a familiar bumping sound. The spare tire has worked loose.

"Of course," he says to his wife, "when the car was going slowly it would not bump, but only when we reached a certain speed. . . ."

WHAT THESE THINKERS WERE DOING

There are several features which should be noticed in these simple trains of thought.

(1) A problem is thrust on the thinker. His activities are interrupted until a solution is found. (In the case of the car-driver the problem was to ascertain whether the engine was being damaged. He did not fully understand the situation till the next morning.)

(2) The intermediate processes, between the perception of the problem and the solution, include the thinking. In simple cases such as these we hardly notice what is happening. In spite of their frequent occurrence in everyday life such cases of thinking are in fact so evanescent that it is very difficult to get people to record them.

(3) There are successive stages in the working out of the solution. The thinker looks about the sun-room, tries to close the window, looks for an implement, forms a mental picture, and so on. The automobilist stops the car, inspects different parts of the engine.

(4) The thinker is using his senses to find out the trouble. He stops, looks and listens. The thinking is not done in a vacuum, but in close touch with reality.

(5) He forms mental images, picturing the physics master, picturing the parts of the car that could make trouble.

(6) By a remarkable power of the mind all these activities are kept relevant to the point at issue. It is as though some superlative dog trainer were walking with fifty dogs at heel. We take this so much for granted that when anything else happens we say with some contempt that a man's mind is wandering.

Once again, although these features of thinking are common, it would be a great mistake to regard them as commonplace, for they lead directly into the heart of the problem. Succeeding chapters will show how this is so.

2. WHEN DO WE THINK?

THE TWO KINDS OF THINKING

THE psychologist gives a special meaning to the term "thinking." If the man in the street were asked about it, he would say that we dress ourselves, eat our meals and do much of our everyday business without having to think about it. He is quite right. It is true that while we are doing these things we are conscious of them, and know what we are doing. But they are done by routine, without reflection, and the psychologist would not say that we "think" as we do them. Perceiving is not thinking, nor is emotion, such as anger, love or fear.

There are in fact two kinds of activity which are properly called thinking. They are sometimes called "free" and "directed" thinking, although a later chapter will show that this distinction is not altogether correct.

A man may go into a "brown study," when the mind runs from one thing to another without apparent direction and with little relation to the environment. I may pass a person I dislike, think of the time I met him last, of what he said to me and what I might have said to him if it had occurred to me in time, and finally be brought back to earth by somebody else calling to me. This is the so-called "free thought," of which there will be more to say later.

Such thinking seems to be wayward and erratic, but it will be seen to follow its own laws.

It is not of course by such reverie that the astonishing technical advances of the last hundred years have been made or humankind has been slowly raised through the ages from barbarism. All this has been done by a kind of thinking that is hard work because it is forced into close contact with reality. Even then, there often seems to be caprice, though not to so great an extent. This "directed thinking" or "reasoning" is of great practical importance. It occurs when we are brought up against a problem which we want to solve.

By "thinking" hereafter will be understood "directed thinking" unless a statement is made to the contrary.

THE THINKER AND HIS PROBLEM

What kind of a situation is a problem situation? No universal answer can be given to the question, since what may be a problem to one man may not be so to another. Whether or not any particular situation should be called a problem depends in fact on the person who is facing it. For example, the situation must be such that thought has time to develop in this particular person. I see that my shoelace is undone, bend down and tie it up. My body is reacting to the situation without my having to think about it, though I may of course have had to think hard when I learned to tie a bow. To an adult swinging on a trapeze this situation would certainly present a problem, or to a three-year-old child or a chimpanzee, provided, of course, that they

wanted to tie the shoelace.

A man wants something. In more technical language he is impelled towards a goal, which must be reached by doing something. Sometimes, however, he cannot take the necessary action at once because the situation holds him up. The man is brought to a stop in his tracks, and organic processes are initiated over a longer or shorter period of time which finally bring the goal within grasp. Whether this happens and how long it takes depends on the man, the circumstances, and the goal.

By "directed thinking" or reasoning is usually understood the conscious side of these intervening processes. By a problem is meant the trouble-making situation, excluding the goal.

Thus, *a problem may be defined as a situation which for some reason or other has held up a person or animal* in its efforts to reach a goal. The delay may have a variety of causes. The problem situation may contain contradictory features, it may be so complex that immediate reaction is impossible, something may be apparently missing, and so on. The problem may or may not be solved; that is, the measures taken to reach the goal may be successful or unsuccessful.

The following examples are actual problem situations reported by two young women.

THE DIME THROUGH THE GRATING

One writes: "I had hurriedly dumped the contents of my purse on the table in an effort to find some small change. A

dime rolled off the table, along the floor, and through the grating of the furnace. A rapid survey showed that the dime had been stopped in its fall on a small ledge eight inches below floor level and that the grating was immovable. I procured a long knitting needle from the drawer, but the dime and the needle had a tendency to evade one another. . . . Talking to myself I heard, 'If the dime and the needle would only cling together.' . . . My eyes fell on a stick of chewing gum lying on a table. Of course! If some gum was stuck to the end of the knitting needle and brought into contact with the dime, it could be withdrawn."

Here the *goal* is the dime. The girl is checked because the situation holds a contradiction. She wants the dime. To obtain it she must get past the grating or move it. But she can *not* pass or move the grating. Processes are accordingly set into operation by which the contradiction is surmounted and the goal reached. *Perception* was active ("a rapid survey showed," etc.). So was *language*. (She was talking to herself, she admits.) *Imagery* was particularly vivid and probably important. It will be dealt with later. There was much muscular activity. And finally there was *insight*, when she saw that the gum would work.

FIRE IN THE KITCHEN

"One winter evening," writes another girl, "as I was washing the dinner dishes I heard a crackling noise. Looking towards the stove I saw that flames were moving up the wall behind it. . . . I remember tearing madly round the

room, grabbing towels and curtains with which to beat off the fire. These seemed very ineffectual, and I knew I would have to use my head. . . . I stopped for a fraction of a second and really thought. I looked towards the dishpan and knew it was what I wanted. I grabbed it and hurled the water on the flames, which were quickly extinguished."

Here the *goal* is to extinguish the flames. The *situation* includes everything in the kitchen—the towels, curtains, water taps, cooking utensils, etc., plus the sound of the crackling fire. The girl is held up in her efforts to extinguish the fire because the situation apparently lacks a way of getting the water to the flames. *Perception* is especially active here, as she looks round the room, and it is rewarded by the sight of the missing means to the end, the dishpan. *Trial and error* is obvious and is accomplished by extreme motor activity.

HOW WE OFTEN SHACKLE OUR THINKING

Now each of these problem situations contains what may be called "conditions." The girl with the dime says the grating is immovable. Of course it isn't. Anybody *could* move it with a crowbar. If a baby somehow got into the register with the grating jammed, or if the Cullinan diamond happened to fall through, a crowbar would probably be used. The girl's problem is to get the dime without breaking the register.

Where are the conditions in the "fire in the kitchen" problem?

They are there unnoticed, something like the "find the policeman" in the children's pictures. The girl could have jumped on the stove and put out the fire with her person, with the certainty of burning herself, and at the risk of killing herself by burning her clothes. In a severe emergency she would probably have done just that, if, again, the life of a young child had been involved. The necessity of not damaging oneself runs through many of our problems, and indeed makes many situations into problems. Heroism occurs when what we may call the "self-regarding postulate" is disregarded. In many military citations for personal bravery we read that so-and-so carried out his duty "with complete disregard for his personal safety." The man who is given the Victoria Cross or the Purple Heart is not the one whose personal safety enters into the situation when he sees a comrade in danger. When courage comes in at the door, reason often flies out of the window. Lord Tennyson recognized the relationship between thinking and regard for one's own preservation when he wrote:

"Theirs not to reason why,
Theirs but to do and die."

With the personal conditions of their problem eliminated, reason was unnecessary for the "noble six hundred."

CUTTING THE GORDIAN KNOT

Almost every problem which a human being has to face carries such conditions, which are really part of the problem itself. The situation "do this *without* doing that" is a very

common one. Thus a student in an examination room is required to get the answer to his mathematical problem *without* copying from the man next to him. A doctor who is faced by a difficult surgical situation must perform the operation *without* killing the patient. It is not good surgery to remove a cancer from the liver, at the same time doing this in such a way that other vital structures are destroyed.

Sometimes it is possible to disregard certain of the stipulations in a way not at first apparent. In this case, the problem-solver is said to "cut the Gordian knot." The original Gordian knot was cut by Alexander, king of ancient Macedon. Plutarch, the Greek gossip biographer, tells the story. "He saw the famous chariot fastened with cords. . . . The inhabitants had a tradition that whoever could untie it, should succeed to the empire of the world. The ends of the knot were secretly twisted round and folded up within it, and Alexander found himself unable to untie it. So he cut it asunder with his sword." The Greek writer adds that there was an easy solution by "pulling the pin out of the pole to which the yoke of the chariot was tied, and then pulling out the yoke itself."

The story shows the military man riding roughshod over those he has defeated. Alexander intended his action to have a symbolic value, which the phrase has retained ever since. But the story is especially interesting to a psychologist because it shows the man of genius cutting through what to ordinary people are the obvious conditions or stipulations in a problem situation.

The recognition of the essential stipulations of a problem and the rejection of superfluous ones is an important part of the activity of thought or reasoning. We ordinary people often let mental timidity or even sheer laziness im-

pose conditions that are not in the situation at all. A certain boldness of thought and character is often necessary to discard apparently obvious elements of a problem.

Thus the older astronomers were faced with the problem of how to explain the motions of the heavenly bodies while the evidence of their senses and the teachings of their ecclesiastics told them that the earth was at rest. As observation piled up knowledge over centuries, the explanation became more and more complex, until the description of the heavenly movements became impossibly complicated. It was left for the genius of Copernicus to cut the incredibly twisted knot that ingrowing human ingenuity had tied. This he did by pointing out that if the earth was not regarded as fixed, but as moving with the planets round the sun, the observed facts could be very simply explained. He saw that a condition which seemed to be part of the problem did not belong to it at all, and that the whole situation was simplified by cutting it away. It takes brains to be an innovator, and often a certain quality of ruthlessness.

The same general point may be illustrated by an account of a laboratory experiment. A young man was given a corked bottle with a marble inside. The problem was to extract the marble *without* pulling out the cork. The following account is condensed from the laboratory notes.

The subject sits down, rattles the bottle, puts it back on the table and looks at it. He takes up the bottle and examines the cork. He asks a number of questions, and finally pushes in the cork. When asked why he didn't break the bottle he answers that he didn't think it was allowed.

Yet there was nothing to that effect in the problem as read to him. The young man was, however, in the labora-

tory, where there is a due sense of the value of property. He was in the presence of the instructor, which, in all probability, acted so as to increase the force of the apparent prohibition still further. In any case, he imported conditions into the problem which were really not there. He saw the problem—the thwarting situation—not as it was, but tied up with unnecessary strings.

A colleague of the writer, when told the problem, answered immediately, "How about smashing it?" (He did not actually see the bottle.) When told that there was another solution, which was to push the cork in, he replied, "That's the kind of thing you people amuse yourselves with!"

Yet this more complicated solution was actually the one reached by the student, who had shackled his thinking by importing an unnecessary condition into his situation.

The fact is that it takes brains, experience, and a certain ruthlessness to smash the bottle, to smash convention, or to smash prejudice.

Human nature is such that the force of tradition or of education, which often comes to the same thing, in many cases adds unnecessary complications to our thinking.

Iles, in his book, *Inventors at Work,** gives an excellent illustration in his account of the invention of the Reynolds ore-crusher. It had always been the practice to crush the ore on a layer of protective timber and rubber, "supposed to be indispensable to efficiency." Reynolds was called in as a consultant, saw an ore-crusher at work for the first time, and at once proposed to build crushers directly on a block of solid iron. The directors were scandalized, and

* New York: Doubleday, Page, 1906.

held out against the innovation for two years; but finally Reynolds had his way. The Reynolds stamp produced 60 per cent more crushed ore than the old one. Its energy was wholly employed in crushing ore, not uselessly in compressing rubber sheets.

Another example given by Iles has to do with the building of a tunnel for the Central Vermont Railway. The experienced engineers spent a large amount of money and finally decided that the tunnel could not be built because there was no way of holding the sandy subsoil. A young man in the engineer's office had observed that sand swallows build self-sustaining tunnels, without any masonry! He drove in stakes to form an arch, hollowed out the enclosed sand, and put up his brickwork. By going slowly he built "the cheapest tunnel ever made," which in 1906 had carried the traffic of a great railway for thirty years, and saved the railway millions of dollars.

Education and experience had complicated the problem by the assumption that the sand lacked cohesiveness. The spurious factor in the problem was rejected by the young engineer because he could look at the whole situation with an eye unprejudiced by habitual methods of thinking. It is interesting to find him going to nature for his pattern.

I am tempted here to give other instances of the way in which a fresh mind can cut the unnecessary strings of a problem. No fact concerning the psychology of thinking is better illustrated in actual life, and that holds for every field of thought—chemistry, physics, the social sciences and psychology itself, to name a few only. The whole topic will be considered later from another angle, and other examples given.

EXPERIENCE AND KNOWLEDGE NECESSARY

What has been said about the strings attached to a problem situation does not of course imply that knowledge and experience are of no use. These are essential in most if not all cases. Hundreds of thousands of years' traditional experience of the way to put out fire were behind the action of the girl who threw the dishwater over the flames in the kitchen. Twenty years' experience of the sticky nature of chewed gum told the girl that the dime would stick to it, and that it would stick to the knitting needle. To make the rock crusher at the Tamarac Copper Mine, a trained engineer was called in, that is to say a man who had at his command all the traditional knowledge of engineering matters accumulated through centuries. And so on. Education and experience are necessary, but the human mind is such that they are often abused. Knowledge is a good servant but a bad master. The competent thinker uses his knowledge but does not let it tie him down.

CONTRADICTORY FEATURES IN THINKING AND HOW WE RECONCILE THEM

Contradiction of some kind or other enters into many problem situations. A person finds himself in a situation where the "*stop!*" and "*go!*" signs are simultaneously pres-

ent. The dime in the problem described says "*go!*" the grating, "*stop!*" Such negative clauses in the problem, as a lawyer might call them, may not be perceived. Charles Lamb's pig was supposed to be roasted by burning down the house. A feeble-minded girl is reported to have bathed a baby in boiling water. In fact, it takes brains to see a problem, apart from solving it. Fools are said to rush in where angels fear to tread, presumably because the fools do not see the "*stop!*" signs. Many great scientists have done their work because they were able to see or to formulate problems which were unnoticed by everyone else. Often, but not always, this is because they saw contradictions which had been overlooked. The medievals used to believe that the water rose in a pump because nature abhors a vacuum. When a forty foot pump did not work, it is said that Galileo ironically remarked that nature clearly abhorred a vacuum only up to thirty feet. His acute mind saw the contradiction between fact and conventional explanation. Later, his pupil Toricelli solved the problem by demonstrating the pressure of the atmosphere. Galileo was not indeed the first to see the problem, for the situation must have occurred many times before. But he was apparently the first to formulate it in the correct way, showing the contradiction between fact and theory.*

When a successful solution is reached, contradictions must be reconciled and a unified or *integrated* line of thought and action devised. This activity of integration, by which the organism reacts to diverse-prompting stimuli with a single unified response or series of responses, is a

* In Chapter 11 another implication of Galileo's ironic remark is mentioned.

most important aspect of thinking. Such integration is obviously a necessity if we are to go on living. Even the naive amoeba, one of the simplest of animals, has to be able to resolve contraditions. If it finds itself in a situation where food at its one end says "go!" while food at its other end also says "go!", it must either pull itself in half, or act as a unified creature with a unified response. It must go in one direction or other, not both ways at once. As we go up the scale, the possibility that the animal will find itself involved in contradictory impulses is greatly increased. One important function of the nervous system as it gradually develops in evolution is exactly to effect such integration; and Sir Charles Sherrington, Nobel prize winner, showed in a series of magnificent researches how this is done on the physiological plane.

Directed thinking is an extension of this same universal activity of integration. A human being is a single organism. He must act as a unity if he is going to survive, even when, as momentarily happens, the environment seems to call for contradictory responses. Sherrington showed how the routine of the body handles many of these contradictions through the central nervous system. We have seen that routine actions do not evoke thought. But when routine is inadequate, often owing to such contradictions, the body is brought to a standstill, and those ultimate processes are brought into play which have been called reasoning or directed thinking. That these processes are integrative in character is natural enough. They are largely organized through the brain, which is a special annex of the central nervous system that nature seems to have developed for the purpose. Through the action of this stupendous mechanism,

the apparently irreconcilable is reconciled, the seemingly immovable moved. It is the integrative action of thought and of the brain that has torn the word "impossible" from many dictionaries. There will be more about this later.

Plato says somewhere that Eris or Discord is the mother of Reflection. He was not so far wrong at that.

Two rules emerge from this chapter:

(1) See that you have not complicated your problem by unnecessary assumptions. Many of the great thinkers have succeeded by discarding assumptions that everybody else took for granted.

(2) Do not be discouraged if your problem apparently holds contradictions. Many problems do; it is your job as a thinker to reconcile them.

3. WHY DO WE THINK?

AMONG my acquaintance are two men whose lots are cast in very different places. One is a successful research man, known across the continent for his scientific work, a well-known teacher and an asset to the country; the other is a hanger-round at pool rooms, who lives in a cheap hall bedroom, picking up an occasional piece of work from advertising agencies, hardly knowing where his next week's rent will come from, doing nothing productive at all. I knew them both well as young men, and they were of approximately equal promise. In fact, the second had if anything rather more "brains." One of his teachers told me that he did his college work "with a kind of contemptuous ease." In personal attractiveness the two were about evenly matched, and also in opportunity and financial position. Why then such a difference after fifteen years?

Each man started with the same equipment. One used it, the other did not. Whatever the reason—and the reason is often difficult to determine—the motive power to work the equipment was present in the one but not the other.

This chapter deals with the psychological motive power behind thinking, or *motive* as it is generally called.

HUMAN THINKING IS MOTIVATED

A human being is not like an appliance such as an electric bell or a piano, where something outside acts directly to produce movement, and the mechanism has no part in determining which response shall be made. Such a description has led to serious misunderstanding of human nature in the past. Every organism has a dual nature. On the one hand it is the marionette of its surroundings. There are indeed many occasions where the environment pulls the string and action follows mechanically. When a speck of grit falls in our eye, we blink, and if that does not remove the obstruction, we weep. When a physician taps a healthy man's tendon below the kneecap, the leg moves with invariable regularity, like the hammer of a piano, though by a different mechanism. This ability of the body to act like a simple machine is literally of vital importance since it keeps us in touch with our surroundings. No man could long survive without it.

But it is only half the story. In much of what men do another factor enters, namely, the needs of the human being, which regulate and select human responses, and of which the most obvious examples are the great primary requirements of food and drink. The needs are of varying degrees of importance and comprehensiveness. The greater breeds the less. The need for food brings the need for money and that again for a profession, which brings the need to go to a professional school, to stand the examina-

tion and finally to solve this particular problem in the examination room.

When any need gives rise to behavior or thinking the psychologist speaks of motivation. All thinking is apparently motivated. The wish is truly father to the thought. It is not enough that a man faces a problem situation. There must be something which makes him interested in solving the problem The girl who lost the dime in the grating would not have bothered with it if she had been hurriedly dressing for a dance. The demands of the moment would have directed her activities elsewhere. The engineer in the last chapter would not have wanted to build the tunnel if he had been employed by the rival railroad. The discovery of the compass is said to have been made by a Chinese emperor who was faced with the problem of punishing a rebel. The rebel, at the head of a large army, raised a thick fog in order that he might spread confusion in the enemy's ranks. But by the use of the lodestone the emperor constructed a chariot which indicated the south, and thus distinguished the four cardinal points. The rebel was pursued and the account tells us that he was ignominiously put to death. All this is said to have happened in 2634 B.C. The fog alone would not have caused the emperor to think without the need to reach the rebel. And by the way, the rebel's motives are made clear in the narrative. "His grasping disposition and avarice knew no bounds."

So important is human need in calling out the processes of thought necessary for invention that some have claimed that the great technical advances have all been made under pressure of some social need. A knowledge of the stars brought a great advantage to early navigators, and the

study of astronomy might well have arisen in this way. The discovery of the first method of computing the longitude of a ship at sea was made when King Charles II of England offered a prize * for it, since transatlantic sailing made the need urgent. The apparently impractical science of geometry was originated by the Egyptians who, when the Nile subsided after its annual flood, could not distinguish each other's property without surveying the ground. The demands of war have been among the most urgent which the race has had to face. It is, therefore, not surprising that colossal technical advances have been made in wartime. The day before this passage was written an account came over the radio of what was said to be the most important scientific discovery ever made, that of the atomic bomb. The organization, the funds and the complicated and systematic thought of hundreds of scientists from many countries that made it possible could not have been effected save under the needs of war, with the enormously strong motivation they provided. Pasteur once remarked that fertile ideas are the daughters of necessity. And another great scientist, Mach, has said that all science has its origin in the needs of life.

Experimentalists have reported striking results obtained by the manipulation of motives. In one experiment young men were given standardized tasks, and their improvement was recorded when they worked alone, and with a partner, with whom each was set to compete. The motive of competition produced over 50 per cent improvement. Children learning to read showed about 400 per cent more improvement when matched against partners. Speed of reaction was

* It was given to the first Astronomer Royal, Flamsteed.

increased 15 per cent by proper motivation. These experiments did not involve much thinking, but they do show the effect of adequate motivation.

One of the technical journals contains an account the truth of which was guaranteed. A schoolboy had been failing in his school work, standing consistently at the foot of his class. On one occasion a visiting uncle promised that if the boy headed his class at the end of the month he should go to the circus to see the lions fed. Thereupon the boy applied himself with great assiduity, staying home at nights, poring over his books and otherwise behaving in a surprising manner. Finally his health began to suffer, and the parents became uneasy. Questioning their son they discovered that he thought he had been told that unless he stood at the head of the class he would be taken to the circus and fed to the lions. Meantime he was at the top of the class. One would perhaps hardly recommend this method of motivating small boys to think, effective though it may be. Nevertheless, something very like it happened wholesale during the war.

Motivation is of fundamental importance in determining whether a given person will or will not think effectively. The brains or intelligence may be there but it will lie idle without the energizing motive, like a printing machine before the power is turned on. For this reason most of us fail to work up to our full capacity. When the melancholy poet, Gray, regretted that there lay unknown in the country churchyard

> "Hands, that the rod of empire might have sway'd,
> Or waked to ecstasy the living lyre,"

he attributed lack of fulfillment to lack of opportunity. Certainly in Gray's time there was little opportunity for the ploughman. Yet two years after these lines were printed, and less than a hundred and fifty miles away, the inventor of the spinning mule was born on a small farm. Crompton had to help his widowed mother with the farm work, and it is said that his legs became accustomed to the hand loom almost as soon as they were long enough to touch the treadles. He was secretly busy with his invention for five years, and it is said that he could not leave the house for fear that his discovery would be stolen. Modern psychology has made it certain that in the poet's time there were many who were if not of equal, at least of comparable ability with Samuel Crompton, but who were to fortune and to fame unknown. Crompton's example shows that adequate motivation could even then overcome considerable lack of opportunity. Of course this is not to say that it was in everybody's power to motivate himself as did Crompton, or that social conditions were conducive to the proper motivation of talent. But it is important to realize that with the methods which modern psychology has developed to detect talent in all groups of society, the social problem is beginning to be not the discovery of the mute inglorious Milton, but rather his proper motivation. Brains lie all around us unused. Today we know where they are, but we are not setting them to work. Unless the reader is supremely fortunate, it is probable that he himself is not motivated to think up to his full power.

EXPERIMENTING ON MOTIVATION

It was a young Scotchman, by the name of Watt who first studied thought-motivation under laboratory conditions. Early in this century the Great Name in Psychology was that of Wundt, professor at the ancient University of Leipzig, who published over two printed pages of scientific writing for every day during the last sixty-seven years of his life, and whose word could make or break a young man's reputation. Now Wundt had stated that it was not possible to investigate thought experimentally. Being a Scotchman, Watt set out to do this impossible thing, together with other young men at Würzburg, a rival university.

Science starts with the simple and proceeds to the complex. Consequently Watt started with a very simple kind of motivation, so simple that at first sight it would hardly seem to come under this heading at all. We have seen that greater needs breed lesser needs in a pedigree which descends to the elementary activities of everyday life. It was at the very end of the process that Watt experimented. His subjects were told for instance, "add the figures you see and tell me the answer." Cards were then shown, bearing for example the digits 2, 7, to which the subject answered *9:* then 13, 22, the answer being *35*, and so on. Other simple instructions were used such as: "name a part of"—horse, chair, dog, etc., the subject answering hoof, leg, tail. When the subject accepted these simple tasks, a need was set up to deal with the figures in a certain way. The subject was

motivated to *add*, or to *name a part of*, whatever appeared before him.

By this apparently simple experiment, which was really the product of great ingenuity and hard thinking, Watt was led to distinguish the two factors in thought already mentioned, an environmental one, for instance the two digits, and an organic one, the "task" as he called it. Unless both were present, he concluded that thinking did not take place. Both stimulus, or situation, and motive ("task") were necessary. The experiment looks easy and obvious now, as most things are when somebody has shown the rest of us what to do and how to do it.

Watt found that with the same situation and person, change of motive might completely alter the nature of thought. For example, verbal imagery (talking to oneself silently) might be changed in this way from 11 per cent to 2 per cent, visual imagery from 50 per cent to zero. In the same way, reaction time, as taken by a stop watch, might also be altered, that is to say the time taken to think when facing a specified situation.

A later worker in the Würzburg group, named Ach, made a further observation. He found that motive can alter the way in which the stimulus is perceived. When instructions were to add, for example, one of his careful observers stated that the figures would seem to be bent or crushed towards each other in a rapid exposure. When they were to subtract, the digits would seem to be bent away from each other. Quite recent experiments have shown that a hungry man is more likely to see food in ambiguous pictures than a well fed one. The effect apparently increases after a three hour fast, and for some material after a six

hour fast, corresponding to the ordinary times between meals. Thereafter it decreases, in agreement with the known fact that hunger is not felt so acutely after a time. In the same way, the financial motive has been ingeniously used to influence perception. When men were financially rewarded for perceiving lines of a certain length and weights of a certain magnitude they tended to distort their perceptions in order to perceive what they wanted. A psychologist has shown that a ten cent piece really does look "larger" to a poor boy. These laboratory results are of course in line with everyday experience. Food certainly "looks different" when one is hungry and after a good meal. I once heard a surgeon speak of the "clean red" of a surgical incision. I have no doubt that, motivated as he was to remove an infected appendix, the blood really did look clean. It looked anything but that to me when I witnessed an operation on a member of my family. Lady Macbeth, with murder in her heart, cries to her dagger: "Mine eyes are made the fools o' the other senses . . . on thy blade and dudgeon gouts of blood . . . *it is the bloody business which informs thus to my senses.*"

MOTIVES ARE OFTEN UNCONSCIOUS

One of the most important of Watt's findings was that the motive is generally unconscious. It is conscious at the beginning, when we adopt it, and also when an obstruction turns up during thought. Obviously the subject has to realize at the start that he is undertaking to *add* or to *subtract* pairs of figures to be given him But once this is estab-

lished, the whole process goes on automatically, without the necessity of saying at each operation, "I am to add this." An automobilist in America does not have to tell himself whenever he turns the wheel that he has to keep to the right. If he moves from America to Great Britain, he will find it necessary to remind himself for the first few minutes that he must now keep to the left; but it is not long before left-hand is just as automatic as right-hand driving was a month before. Clearly the interests of mental efficiency demand that motives shall generally be unconscious. One may expect that a surgeon who had to remind himself every time he made an incision that he must not kill the patient, or a bookkeeper who had to repeat "add this figure to the last" at every digit when he was totting up a line of figures, would soon be changing his occupation. If our interlaced motives were not unconscious, the mind would probably break beneath their weight. This is obvious when one considers their complex structure and organization—the bookkeeper adding a row of figures because he *wants* to see how much this row of figures amounts to, and this because he *wants* to hold his job, and this because among other things he *wants* his pay check, because he *wants* to earn money for himself and his family, because they and he want, among other things, to eat. Man must be able to keep this complicated structure out of his mind while he is thinking or acting.

The manner in which unconscious motives may direct thought is well seen in an experiment of Ach's, who will be remembered as another member of the Würzburg group. Ach hypnotized a subject and told him: "Two cards will later be shown you, each with two figures on them. When

you see the first you will name the sum, when you see the second you will name the difference." The subject was awakened. After a few minutes' trivial conversation Ach held up first one card and then another as arranged, and the correct answers were given. When questioned, the subject said that he did not know why he had said either of the figures, but claimed he had answered "Quite casually . . . I had the *need* to say eight." There are a number of associations clustering round the figures 6/2 which were on the first card. Six and two are eight, six minus two are four, and so on. Ach claims that it is ultimately the *unconscious motive* which decides between them, although he has a different term for it.

Ach also speaks of the surprise which his motivated subjects experienced when something turned up contrary to their expectations. This surprise he claims is also due to the existence of the unconsciously working motive. Surprise often occurs in everyday life when something about which we have been thinking turns out contrary to expectation.

Unconscious motives reach down to the very foundations of a man's personality, where they work subterraneously. Freud, the founder of psychoanalysis, was the first to recognize the importance of this fact in his treatment of the mentally sick. I knew a young man who was deadly afraid when he had to go to the barber. As many of these abnormal fears originate in the family situation, he was questioned about his relations with his mother and father and two brothers. He replied that he was on good terms with them all, and had a particular admiration for his elder brother who had founded the business in which he worked. It was only after months of questioning that the true state

of affairs was uncovered. Actually, he had intensely aggressive wishes against his brother. At the final scene, when asked what he would do to the brother if he had the chance, without fear of retribution, he jumped up, ground his heels on the floor with an indescribably vicious expression on his face, and cried, "Such a man ought to be ground into the earth. His face should be smashed into a pulp." Yet for fifteen years or so he had been genuinely and completely unconscious of the shatteringly powerful motive.

The motives with which psychopathologists deal differ in one respect from those considered earlier. Both may be unconscious; but ordinary motives can easily be brought into consciousness while those with which the psychiatrist has to do are uncovered only with difficulty. The young man had an urge, to kill his brother, which the conditions of society prevented him from satisfying. He had seen his brother shave with an old-fashioned razor, and was afraid, without realizing this, that one day he might kill his brother with it. This disguised itself as a whole host of fears, fears that girls might notice that his beard was not very heavy (he had a very light beard), fears that he could not do his college work, fears that he might not make good in life, as well as the primary fear of entering a barber shop. All these endless fears were motivated by the unrealized wish to kill his brother with the correlative fear that he might do so. He recovered when his true motives were explained to him, which involved much patient work, and severe mental anguish on his part.

DAYDREAMS ARE ALSO MOTIVATED

What about "free thinking," reverie, the brown study, those often long meandering chains of thought which seem so insubstantial and inconsequential? Is "free thinking" motivated?

I am at breakfast with an old lady, a house guest who is inclined to be garrulous. Mrs. L invites me if ever I come to her home town to be sure to visit her. I answer that I shall have to pass near her home on my way to a committee meeting. I think to myself, "X will be on that committee."

Then the brown study starts! I think how I shall answer X's last letter which was a little peevish, and also concerned a committee meeting. I think, "X's success has gone to his head. He's not had much success anyhow." I find myself thinking about another friend, Y, who had not answered a letter of mine. Success seems to spoil people. . . .

I come to with a start. My house guest is saying: ". . . need to have it ploughed up. That's the only way you can get it clear." I have no idea what it is all about. She has been talking for some minutes without my hearing her at all. I apologize.

Surely this long and, to an outsider, rather dreary mental rigmarole is unmotivated, undirected by any need of mine?

Actually, it is directed by one of the most important human needs, the need for self-esteem. Owing to various circumstances I had been feeling "sore" and disappointed. Out of all the possible "associations" that could have been

brought up by the original committee meeting, X's name was selected by the need-motive for self-reassurance. I have to put myself in the right with X. So I think of the letter I will write to him, and discount his success. The same motive brought the thought of Y, who had not answered my letter, and I depreciate her also. Not a very noble set of motives, the reader will think. But he who is entirely without this kind of sin may cast the first stone. If, on reflection, any reader decides that he is superior to this kind of thinking and motive, I am inclined to suspect that he is not sinless but unobservant of what goes on in his mind.

Actually, all fantasy and daydreaming is motivated, generally, by the semi-emotional, personal urges of the thinker, although this is not always the case. Most fantasy differs from reasoning in that less account is taken of the demands and conditions of the outside world. It is easier to think of getting one's own way than to get one's way against the difficulties of the world in which we live, and for that reason fantasy is dangerous when it is allowed to play too large a part in mental life. That is why children are properly advised to "do noble things, not dream them all day long." Freud uses the term "thinking on the pleasure-pain principle" because he believes that here it is considerations of pleasantness or unpleasantness that motivate the thought, rather than the reality of the world outside us.

The plight of the young man afraid to enter a barber shop shows that fear as well as self-esteem may also be father to the thought. This may also be seen from the experience of the man who worries. If he is afraid he will lose his job, he will start thinking about what will happen if he does lose it, how he will make the payments on his house,

educate his children and so on almost forever. The poet Hood tells of watching a dying girl, where fear and hope motivated thought alternately.

> "We thought her dying when she slept
> and sleeping when she died."

To allow such trains of fear-motivated thought to occur in excess *is* in fact to worry. That such worry-thinking is, like all affective thinking, relatively far removed from reality is illustrated by the remark of the man who said that he had worried about a good many things in his time, but that none of them had ever happened.

It is important to remember that, like directed thinking, the daydream, also, is as a rule started by some external event, however far it may wander it is thus anchored at one end to reality, like the spider dropping on a single strand from the ceiling. In this way it differs from directed thought which is anchored at every step to the world outside. Experimental evidence seems to show that it often occurs when in the course of reasoning some insuperable difficulty turns up. This is perhaps the reason for some at least of the long thoughts of youth, for the world presents a hard and often an insuperable-seeming problem to the young.

WHAT ARE OUR CHIEF MOTIVES?

What kind of motives activate the thinking of the average man? A man (or woman) must first satisfy his primary needs—food, air, drink, warmth, and so on.* Many of these

* This is not intended as a complete list of the primary needs.

we share with creatures much simpler than ourselves. The simple amoeba must have food and water. The frog needs air and food and warmth. The dog's elementary needs are very close to those of the human being. Much experimentation has been done with animals. For example, it is known that the maternal drive in rats is slightly greater than that of the hunger and thirst drives at their maximum. It is greater than that of the sex drive at its maximum, but decreases as the age of the litter increases, and also as the age of the animal increases. It decreases also if the mother is separated from the litter for four hours preceding the test. The tests were made by requiring the animal to cross an electrified grill. Strength of drive or motive was measured by the intensity of shock which the animal was willing to receive. One should be careful not to apply these results too literally to human beings.

Much of our thinking is ultimately motivated by these primary needs. A young man must have bread and butter; he wants to be able to marry. Such needs obviously influence the way in which he responds to his environment. Whether the sexual urge should be reckoned among the primary needs is under dispute. Certain it is that the urge is very powerful both in human beings and in organisms a long way down the evolutionary scale, but it is doubtful whether it should be placed in the same class with the need for food, for example. Many people go through their whole life without sexual experience. Animals are only motivated sexually at certain times. Many very old people seem to lack this source of motivation altogether.

The primary motives take somewhat the same place in psychological theory as instincts a generation ago. Psychol-

ogists used to draw up long lists of instincts, unlearned modes of response, which they thought should be attributed to human beings. Many wrote as though an instinct was some mysterious intuitional force which told an animal or human being what was to happen in the future, and what to do in the present. Science found the concept of instinct dangerous, and now prefers to think of the motive arising from a need, which is present because the organism is constituted in a certain way or which is acquired. This is not, of course, a final explanation, but experience has shown that such a description is less dangerous and more productive than the older one in terms of instinct.

Springing from the primary needs, in the way already mentioned, are a host of secondary ones. There is the need for human companionship, the need to excel, the need to conform, to do a good job of whatever one is doing and so on. Many of these derived needs have at one time or other been considered instinctive or unlearned.

Thus during the first war we used to hear much about the "herd instinct," but it is doubtful whether a child brought up without human companionship for the first ten years of his life would miss the society of others. The Wild Boy of Aveyron, who lived some years alone in the forests of France at the time of the French Revolution, ran away from the hunters who first saw him, and it was not until he became cold one day that he voluntarily approached a farm house. (It is interesting that the primary need for warmth has been regarded by some experimentalists as motivating certain animals to build nests.) The "wolf children" of India showed no desire to follow other human beings, either native or white. They had learned to associ-

ate with the animals in company with which they had been fed and kept warm. Other children were kept in the same room with them after they were captured, but although these played and chattered to each other, the "wolf children" were uninterested and indifferent.

But although the need for human company is probably secondary and acquired in human beings, nevertheless the herd motive is very strong in our society. No doubt it is at least in part responsible for the enormous growth of cities, both in ancient and in modern times.

Financial gain is another important secondary motive in our present society. Seven hundred and ten inventors, questioned about their motives or incentives for inventing, mentioned nine different motives of which the four most frequent were love of inventing, desire to improve existing devices, financial gain, and perception of a necessity or need.* Taken altogether, these accounted for about three-quarters of the motives mentioned. Others were desire to achieve, the fact that inventing was part of their work, desire for prestige, altruistic reasons and finally laziness, that is, the desire to save themselves trouble. It seems from this and other studies that the inventor has a love of inventing, but that the direction in which he turns his talent is greatly influenced by the prospect of financial gain. It is of great interest that none of these people mentioned any of the primary motives as directing their thought and action. Money seems to stand between human beings and their primary needs, as a kind of motivational middleman, which is perhaps the reason why so many of the moralists have de-

* J. Rossman, *The Psychology of the Inventor*. Washington Inventor's Publishing Co., 1931.

nounced it. Nobody likes the middleman. The importance of the financial motive was recently appreciated by income tax officials, who found that, in spite of the pressure of war, people would not work overtime or even for the regular work hours if by doing so they put themselves into a higher tax-bracket.

The needs of which we have spoken are numerous, and are common to large numbers of human beings. When we come to the momentary needs of the day, which are derived in turn from them, the number is countless. As we have seen, almost every routine task of daily life springs from a momentary need. Here is a door left ajar. Do I open or shut it? Here is a suit hanging on a chair. Do I put it on or hang it in the clothes-closet? Here is a fork in the road. Do I turn right or left? A pair of figures. Add or subtract, multiply or divide? All of them are situations, for which we can call out one habit or another. It is momentary motive or need that decides which one.

Both because of its practical applications and because of its theoretical place in psychology, the problem of motive is probably the most urgent one facing the psychologist today. It is motive that decides what people shall think and do, and this is almost the same as saying that motive determined what they are. To the psychologist, much of the urge behind the political revolutions of the last hundred and fifty years has been the desire to do away with certain motives, such as that for personal profit, and to substitute other more highly socialized motives for them. The astonishing feat of the Russians and also of the Germans in largely changing the motivational foundations of a whole generation of young people in a few years shows what can

be done in this direction. Unless the Western nations can with equal skill direct the motives of their young people into more socialized channels, the outlook would seem dark for our society.

The 710 inventors mentioned earlier may be presumed to comprise a group superior to the average. Yet when asked why they spent laborious days of thought on their inventions, only twenty-two, or about 3 per cent, gave "altruistic reasons" as the answer. Is this good enough? Can a relation be found between this answer and the fact that out society has twice, within the memory of the present generation, been rocked to its foundations by war?

Remember then that without your realizing what is happening the motives you carry round with you decide how you behave and think in the everyday situations of life. If you are angry about something, perhaps because a business rival has outstripped you, then your thinking is governed accordingly. You feel that the newsboy who shortchanges you is deliberately trying to cheat you, the laundryman who wears a hole in your shirt is in league with the manufacturers to increase sales, your friend's casual remark is intended to annoy you. But if you are in love and feeling on top of the world, you smile tolerantly at the newsboy—maybe he is absent-minded because he is thinking of the girl he is taking to the movies tonight. On these days the hole in your shirt shows that you need a wife to look after your clothes, and your friend is a good fellow who knows you can take a joke. Your motives make you see things and people differently. If your motives are healthy, you will be a healthy-minded person. If they are not, if, for example, you have what is known as an "inferiority com-

plex," where your whole life is spent trying to make up a real or imagined deficiency in yourself, you see the world and the people in it accordingly. That shrewd observer, Lord Bacon, remarks that "whosoever hath anything fixed in his person that doth induce contempt hath also a perpetual spur in himself to rescue and deliver himself from scorn. Therefore all deformed persons are extreme bold first as in their own defence as being exposed to scorn, but in process of time by a general habit. Also it stirreth in them industry . . . to watch and observe the weakness of others." And in modern times, in the second world war, Doctors Grinker and Spiegel have found that an aviator with unhealthy motivation is less likely to endure the stress of modern battle. The motto of a famous English school is: "Manners Makyth Man." It might with equal justice be said that: "Motive Makyth Man."

Thus, it is motives that decide whether we shall undertake a problem. We shall see later that it probably has an even more important job to do. The great rule that comes from this chapter is this:

(1) Thinking must be motivated. Make sure that you really want hard enough to solve the problem.

If you wish, you may add:

(2) Watch your daydreams. They also are motivated, often by wishes of which you should not be particularly proud.

(3) If you worry excessively, your thought and action is being chronically motivated by fear. Find out what you really fear, if you can. If you cannot, go to a psychologist or psychiatrist. It may pay you many times over.

4. THE STAGES OF THOUGHT

WATCH this child building a house of blocks. He is thinking hard, and talking out loud.

"This one here. No, that one is better. That's a big one. Then this red one in the corner."

He stands back for a moment and looks at what he has done. He takes out the red one and puts a yellow block in its place. He goes silently to work for a few minutes, building up the walls. One of the walls falls down, and he goes to work more carefully to build it up again. As likely as not when the whole thing is finished he will push it over and start again on a different plan.

Now watch this adult trying to solve a metal puzzle with rings that have to be freed from a central rod and a chain running inside them. He is in the laboratory, but is not particularly self-conscious or embarrassed, because the experimenter has talked to him for a while and smoked a cigarette with him. He takes up the puzzle, looks at it closely, moves one of the rings a little, finds it does not go, and moves it back. He lays the puzzle back on the table, gazes at it for a few seconds, and takes it up again, this time making a more serious attempt to remove the end ring. He fails. He takes hold of three of the rings and tries to force them off, without success. And so on, until almost

by accident he makes the movement which frees the end of the chain, and the puzzle is as good as done. Meanwhile he has rattled the rings, aimlessly slid them back and forth, gazed at the ceiling, put the puzzle back on the table and gazed at it, fingered it again, and so on, the whole process occupying nearly seven minutes.

The young child and the adult have both used much the same method, known by the psychologist as *trial and error.*

Practically always in thinking there is more or less deliberate trial of one solution after another until the one that works is found. The baby with the blocks quite naturally talked his thinking out loud, the adult mostly acted his out. Psychologists have often asked adults in the laboratory to talk out loud as they think, but it is found that this often tends to interfere with their thinking, and the method is avoided where possible.

TRIAL AND ERROR IS UNIVERSAL

Trial and error has been found a long way down the animal scale. Something like it occurs in the very simplest forms of animal far below the stage where the nervous system has developed and thus, as far as we know, before thought itself is possible. For thought, as it has been defined in this book, seems to depend on a highly evolved nervous system.

The Stentor, a trumpet-shaped, single-celled creature of microscopic size, uses first one reaction then another when disturbed by a strong stimulus. These "trials" follow in regular sequence. First the animal bends over to one side.

If the disturbance is continued, it reverses the direction of the movements at the top of its trumpet which bring it food. If this does not succeed, the animal contracts strongly upon its stem, like a spiral spring snapping to. Finally, if the disturbance still persists, the Stentor breaks away and swims off.

Much farther up the scale, the earthworm has been taught simple lessons involving a turn to the right or left and has been seen literally to feel its way towards the goal. The turtle has been placed in a maze of very elementary design, which he solves by blundering his way out, making mistakes, retracing them, making others and retrieving these again, until he finally gets to his food. On subsequent occasions there are fewer and fewer abortive trials, until the path is comparatively direct. When we come to such intellectual aristocrats as the cat and the dog, instances of trial and error are abundant. A cat placed in what is called a puzzle box thrashes round, mews, tries to squeeze through the openings, puts its paws through the bars, claws at anything it can reach. When it strikes anything movable, it often continues to work there. This may go on for eight or ten minutes, until, by sheer accident, as it appeared to the experimenter, it happens to work the releasing mechanism, which might be a string or a loop.

The animal tries round until it hits on the solution, and as learning progresses the trials become fewer and fewer.

Can experiments on earthworms and cats tell us anything about the astonishing human mind? They can, for the same fundamental process appears in these experiments and in the highest flights of the human intellect. The most difficult mental operation we perform, and the one which is at the

root of scientific and all other knowledge, is the act of generalizing, by which we draw valid general conclusions from a group of particular objects or events. All experiments on human generalizing show "trial and error" if the problem set is difficult enough. The point will be raised again in a later chapter, but here is a simple example. When people were asked to find the plan or rule according to which certain cards were marked, they tried out first one idea and then another until they discovered the one which fitted all the separate facts. When others, again, were asked to find the rule which would bring success in playing a game akin to dominoes, they used the same method. The great discoverers in the physical sciences such as chemistry and physics relate that they try first one solution to their problem, then another, until they find one that works. There are of course occasions when the solution appears immediately without the necessity for trial and error, but these are comparatively rare. Even when this does occur, the solution has generally to be polished up and completed, and this process is accompanied by trial and error.

Some may think that intellectual creation is not the highest form of human thought but may rate artistic creation higher. In a celebrated letter, Mozart, perhaps the greatest of all lyrical composers, writes: "When I feel well and am in a good humour, or when I am taking a drive or walking after a good meal, or in the night when I cannot sleep, thoughts crowd into my mind as easily as you could wish. Whence and how do they come? I do not know and have nothing to do with it. *Those which please me*, I keep in my head and hum them; at least, others have told me that I do so." Many possibilities occurred to the composer. Of these

he selected some and rejected others, according to the principle of trial and error. Beethoven used the scissors and paste method. If a phrase of music did not please him, he used to paste over it a piece of paper with an alteration written on it. Often this did not please him either, and he repeated the process. Some of his admirers once reverently removed several successive layers and found that the phrase he had finally adopted was the original one!

Even that strange creature, the mathematical discoverer, half artist and half scientist, uses the same method. An eminent research mathematician, Dr. Hadamard, tells us that he makes many more mistakes than his students. The difference is that he always corrects his errors, so that no trace of them appears in the final result. His mathematical insight tells him that the calculations do not look as they should. When good mathematicians do make mistakes, he says, which often happens, they soon perceive and correct them. It is comforting to the rest of us to hear that even eminent mathematicians do not always get these things right the first time.

And finally trial and error even seems to be used by our body in certain difficult adjustments without our knowing anything about it.

Those who have tried it know that a housefly is very difficult and in fact almost impossible to swat when it is in flight. The insect is easy enough to follow while it is moving smoothly, but when it turns suddenly the eye loses it. This has its reason. Photographic techniques have shown that a regularly moving object can be followed with clear vision if it is not moving too fast. But if the direction or speed suddenly changes, adjustment must be made by an

entirely different kind of eye movement, a kind of corrective jerk during which vision is greatly reduced if not altogether absent. When the fly suddenly changes its course, these corrections are made by the eye, vision is lost for the moment, and so is the fly. Quite unknown to the swatter, the eye movements have used the method of trial and error, with an unsuccessful attempt at correction. In a laboratory instrument, irregular movements are followed by the eye, which follows them during the regular parts of the movements. When the motion suddenly changes, the eye loses sight of the moving object and ultimately succeeds in catching it again. A successful adjustment is made through the proper correction. The fly depends for its existence on its ability to dodge better than the machine!

Trial and error thus appears to be an *almost universal procedure of living things when they are adjusting to a difficult environment.* Since thinking occurs when a problem, that is to say a difficult situation, is faced, it is not surprising to find that such thinking nearly always involves trial and error. It has even been shown mathematically that machines, when they break down, will adjust by a similar method.

HOW WE USE TRIAL AND ERROR IN OUR THINKING

The human being has of course improved on the elementary push and pullback that the earthworm uses, or the scratch and bite of the cat. Our superior equipment is able to save us much of the rough-and-tumble of performing

many useless activities. In general, the animal tries out actions, while we tend to try out what we call ideas. Mozart did not find it necessary to have a full orchestra play over all his rejected musical thoughts, and he probably could not have composed at all if this had been necessary. Instead he tried his ideas "in his mind."

A very candid young woman reports that one Sunday morning she did not want to go to church. Instead she wanted to stay at home and read. She tried to think up a pretext. Should she tell her parents she did not like the minister or the choir? Neither of these excuses would be accepted. She could not say she was not well, for then she would be kept in the house all day. If she offered to get the dinner she would not be able to read! Suddenly "the light came." She would say she had to review a book for her reading club. The excuse worked; she "received a lecture on not getting things done in time," the family went to church and daughter got her book read. "I had a lovely time!" she says.

Here the problem involves the thinker's relations with people. The problem situation is a social one, as so often happens in our everyday thinking. Trial and error is all done "in her head." In fact, an actual trial of each excuse would have been impossible, for if she made one unsuccessful excuse, she would not have had the chance to make another. This kind of problem could only have been solved by a human being, with the power to think things out instead of trying them out.

Many such problems do not admit of a second try. When these are solved by human beings it is because they are able to try out the unworkable solutions in their head

instead of actually testing them. A wit has said that a doctor's mistakes lie eight feet below ground, while a lawyer's hang eight feet above it! No doctor can have a second try at a dead man. These problems, which have to be solved entirely without actual, *overt* trials, as they are called, are probably not in the majority. More often human beings apparently mix overt with *covert* or "mental" trial. The famous mathematician Gauss tried for years to prove a theorem; then the solution came to him "like a flash of lightning." Asked how he came to discover the law of gravitation, Newton answered, "By always thinking about it." These two famous men no doubt included paper and pencil mathematics in their protracted and unsuccessful trials. Writing mathematical formulae on paper is of course "overt" action, though of a highly symbolic kind.

PEOPLE ONCE BELIEVED THAT THINKING IS NOTHING BUT MENTAL TRIAL AND ERROR

All this added together seems to give an easy answer to the question: How do we think? Indeed, a generation ago many psychologists were saying: "*Thinking* is *mental trial and error. Animals have to act out their trials, while we can think out ours. In this we make great use of language, which is action of a complicated kind. In general, children speak out their thoughts; we speak them to ourselves. Talking to oneself can be shown by the proper instruments to be ordinary talking on a scale too small to be heard. So that all thinking is ultimately trial and error of actual movements, some large enough to be seen or heard, others so*

small that they need modern instruments to detect them."

This account of thinking seems reasonable at first sight. It does bring the thinking of human beings into relation with the more elementary processes of animals. We know that, physiologically, living creatures are descended in an unbroken line from the simplest organism to man who is the most complex of all. One may reasonably believe that thinking in human beings has a similar unbroken descent from the relatively irrational activities of the animals. Such an account as the one just given does seem to show how our improved-model nervous system confers on us the gift of human thought. Like other improved models, the human brain does a better job than its predecessors. It is, so to speak, designed for your comfort, convenience, and economy. It is much more comfortable, convenient, and economical to sit in the cave and use your human brain to think out the best plan of attacking your enemy, than to try an unsuccessful plan. And as we shall see later, research has confirmed the fact that during thought there do occur slight, imperceptible movements of the part of the body concerned, and especially of the muscles involved in speech. The trial and error theory of thinking is then an attractive explanation. Indeed, almost the only thing wrong with it is that it does not explain. We shall see why this is so.

WHY TRIAL AND ERROR DOES NOT "EXPLAIN" THINKING

Briefly, the theory is too mechanical and too superficial. It had its beginning in the learning experiments of a generation ago, on which the original trial and error hypothesis

was based, and which seemed in return to lend it a solid foundation in evolution. From animal learning it spread to human learning, and also to thinking. When the trial and error theory of animal learning collapsed under the weight of experimental evidence, the trial and error explanation of thinking was left hanging in mid air without visible means of support.

What caused the trouble was largely the errors. A trial and error theory demands some explanation of how errors are eliminated. And here opens one of the most startling chapters in modern psychological experiment.

The earlier experimenters found their subjects, human and animal, gradually taking less and less time for the problem, because fewer and fewer false moves were made on successive occasions. A cat's time in the puzzle box may drop from as much as forty minutes to a few seconds: a human being timed on a mechanical puzzle took six minutes and thirty-seven seconds the first time, ninety-one seconds the third time, and one and two-tenths seconds the eighteenth time. Errors have been dropped in both cases.

How?

The answer that used to be given was ingenious. Practice makes perfect, it was said. Exercise improves a movement, and by dint of successive trials the correct movements were made more often than the incorrect ones. Whenever the cat got out of the puzzle box she necessarily pulled down the loop hanging from the ceiling, and she sometimes did other things as well. So that the habit of pulling down the loop was established at the expense of all other habits, much as the habit of parting one's hair is established at a particular line on one's scalp.

The trouble was that the theory did not stand up to experiment. For when *repetition and nothing else* was tested, it was found that it has no effect at all in establishing a movement. The experiment has been repeated in a number of different forms by Thorndike of Columbia, who was originally one of the chief advocates of the law of use or exercise, as he called it. Always the same result came out. In one of Thorndike's many experiments people were required to draw a four inch line, with their eyes shut, and thus without being able to check on their performance, time and time again until they had done this three thousand times. The most frequent lengths actually drawn were 5.0, 5.1, 5.2, and 5.3 inches. These lengths turned up just as frequently at the beginning as at the end of the experiment. A few lines were drawn exactly four inches long. These were no more frequent at the end than at the beginning. This experiment is one example of the many that have shown that practice does not of itself make perfect. Correct movements are not fixed merely because they are repeated. One habit is not improved at the expense of others *merely* as the result of reiteration, however long drawn out. Nor is it possible to get rid of false starts either in action or in thought by merely repeating the correct moves.

At first sight this result of Thorndike's seemed extraordinary and against elementary common sense. But for that reason it should be welcomed. It is exactly when science tells us something unexpected that we should listen particularly closely to her. It is, in fact, not until scientific discoveries begin to shock what seems to be everyday knowledge, as when Galileo showed that the earth went round the sun, that we know our science is getting somewhere. In the

case at issue, common sense is really not so much outraged as would appear. Repetition does not improve the performance of our errors; we would not want it to do so. Every schoolteacher knows that aimless repetition dulls performance, rather than improves it. It is *repetition plus* that brings improvement, and the something plus often falls under the heading of motivation, such as the desire to improve, desire to beat the other man, and so on, though this is not always the case.

One who cares to go to the greatest of all teachers may read: "Use not vain repetitions, as the heathen do: for they think that they shall be heard for their much speaking."

There are many experiments besides Thorndike's by which the "law of exercise" has been tested and found wanting. Truly it is a law that is more honored in the breach than in the observance. It is as thoroughly discredited by scientific research on both men and animals as ever was the idea of perpetual motion or the belief that night air is bad for health. Other "laws" of the trial and error theory have been exploded with equally destructive effects. We must look elsewhere than to blundering "trial and error" and automatic elimination of mistakes for an explanation of animal learning.*

Once the blunder and stumble-into-it explanation of learning has been demolished, the explanation of thinking that grew out of it is much less plausible. Stripped of the evolutionary background that made it so attractive, the theory that thinking *is* mental trial and error and nothing

* It is only fair to say that Thorndike himself now believes he has shown that repetition plus a favorable effect brings improvement; many other psychologists do not agree with this statement.

else can easily be seen not to work.

It will be remembered that the irrepressible Micawber in Dickens' novel was perpetually out of funds and out of a job. Nevertheless he was always hopefully waiting for something to turn up, waiting, that is, for chance to throw into his way something that would solve his difficulties. He was the epitome of the theory that the human being thinks or does everything he can, hoping that the right course of action or the right thought will happen along.

But observe! *When the right thing came, Micawber recognized that it was the solution.*

When a cat makes a series of random movements at the end of which she gets her fish, she has no doubt that she has got what she wants. When a child is trying to build a high tower of blocks by piling them at random on each other, there is little doubt when he has arranged them correctly, because they stand upright instead of falling down! But when the man in his cave sits and rejects one plan after another to defeat the enemy over the hill, how does he know that these are the wrong plans? Not by going out and trying them! And when the mathematician "after months of thinking over a problem suddenly saw the solution like a flash of lightning" as he was stepping into an automobile, how did he know that it was what he wanted? And how did he know that the solutions that had previously occurred to him were wrong? Something other than merely making enough mistakes is necessary before a mathematical problem is solved or a successful military operation planned; something, again, plus trial and error, and by which "mental" mistakes are detected and correct solutions recognized. In a later chapter we shall see what

certain psychologists have claimed this plus factor to be.

The truth about trial and error is now fairly clear. It gives a description of a certain aspect of learning and thinking, but no explanation of thought. It is almost always found when we think. This is an experimental fact of great importance, but it gives no inkling of how we ever reach or recognize a "conclusion." For all the theory can tell us, we could never recognize a mistake without trying it out in action; and even if we recognized mistakes we could not tell when we had reached what we wanted. Once started on a problem we would go on thinking for ever! Time and time again in the many examples of thinking I have collected the thinker says: "I saw that this would not do," "I decided this was no use" or words to that effect, and then follows some such phrase as "Then I knew I had what I wanted." All this is unexplained by the trial and error theory of thought.

The trial and error theory was itself an error which it took science twenty years to correct! It has performed a valuable service, because it has brought the facts into the open. Whatever theory of thinking is ultimately adopted by science—and there are those who think that there is at present no satisfactory explanation of this part of the problem—the fact of trial and error must be incorporated into it. And, as a great man once observed, the fairest fate of any theory is to find itself and the facts that it has uncovered absorbed into a more comprehensive system.

HOW HABIT CAN MAKE FOOLS OF US

The best thinkers do then make false starts and correct or reject them. This seems to be the way of all human reason. Can any help be given which will enable the thinker, that is to say you and me, to shorten this apparently wasteful process? Experiment has some interesting things to say here. First of all, mistakes often appear to be imported from successful solutions of other problems. The Duke of Wellington was one of the most successful soldiers Great Britain ever had. He was

> ". . . England's greatest son
> he that gained a hundred fights
> nor ever lost an English gun."

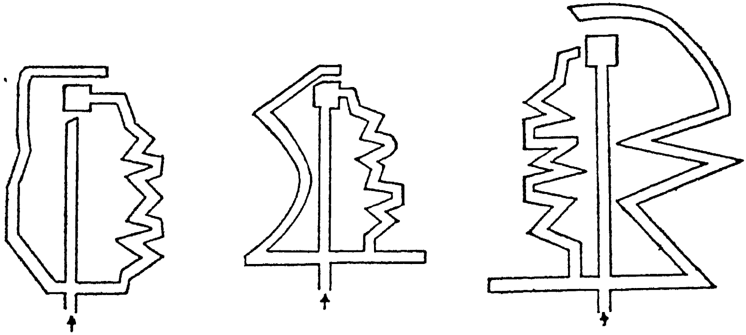
And yet he was "hardly anything as a statesman." Great though his reputation was, he could not dragoon the British public as he had dragooned his guards. Highly qualified and highly successful young scientists who were once at Washington for the purpose of making the world safe for the atomic bomb were described by a political hostess as "refreshingly inadequate." They found that human beings did not work the same way as atoms.

In the laboratory it has been found that a plan of action that has worked on certain simple problems may carry over into other problems where it is out of place. It has been learned so thoroughly that it is followed "mechanically into failure, even though simple solutions were obvious."

The experiment was done in New York on a group of primary school children by a young psychologist called

Luchins, whose research might be entitled "How Habit can make fools of us."

School children up to fourteen years old were told to trace six different mazes of the type of maze 1, where the correct path is the crooked one. They were then given maze 2. Between 75 and 91 per cent still took the crooked



Maze 1. Maze 2. Maze 3.

How habit can make fools of us.*

path. Following this they were given maze 3, in which the goal *could not be reached at all* by the crooked route. Between 60 and 70 per cent still took the crooked route. Very similar results were obtained with adults. This kind of mistake does not seem to depend on age or education. Instructions to be careful had little effect. The children seemed to have been motivated by the desire to get "what teacher wants"; a similar motive may have influenced the adults.

* Mazes 1 and 2 are identical with those published in Dr. Luchins' monograph entitled *Mechanization in Problem Solving*. (Psychological Monographs, 54, 6, 1942.) As used in the experiment the three mazes were of approximately the same size. Mazes are reproduced by the courtesy of Dr. Luchins, who furnished copies of those actually used.

When analyzed the results seem to indicate definitely that this blind following of habit is not due to "human nature" in general but to special factors such as the way children have been taught. Many of the children in this experiment would ask, for example, "When do we get our marks?" They expected marks for getting the right answer, and they expected the right answer would be obtained by doing what they had practiced!

RULES FOR REASONING

It was shown by another experimenter that the proper kind of instruction can do much towards cutting down false trails. Norman R. F. Maier of Michigan was interested in the fact that people often persisted too long at an unproductive line of attack on a problem. He took his group and lectured them for twenty minutes, giving the following instructions. (1) "Locate a difficulty and try to overcome it. If you fail, get it completely out of your mind and seek an entirely different difficulty. (2) Do not be a creature of habit and stay in a rut. Keep your mind open for new meanings. (3) . . . Keep your mind open for new combinations and do not waste your time on unsuccessful attempts." * A difficult problem was then given them to solve. The number of successes in solving it was doubled!

It is probable that Maier succeeded in improving thought because of the talk he gave about his instructions, while Luchins failed because he simply gave instructions without impressing them on his adults and children.

* *British Journal of Psychology*, 1933, 24, p. 147.

Maier says that successful reasoning is at least in part the overcoming of habit, which, we may add ourselves, often causes us to make avoidable mistakes.

HOLD TO YOUR STRATEGY, VARY YOUR TACTICS

Maier's experiment shows the value of intellectual open-mindedness. Stubbornness is damaging not only in the formation of character but also in the solution of difficulties. Of course it is necessary to be stubborn enough to persist in the face of obstacles, but one must be willing and able to change a line of attack when it has proved fruitless. The good thinker is inventive and flexible enough to improvise alternatives as he goes along. One has to make certain whether or not a particular line of action or thought is necessary; if it is not and if success does not follow it an alternative must be found. This flexibility is shown in details, rather than in the grand plan. The strategy of thought, its general aims, must be carried through, in spite of all difficulties, with all the persistence one can summon. The tactics must be altered to suit the particular difficulties that arise during the process of solution.

It took Field over eleven years to lay the first permanent Atlantic cable. When the feat was finally accomplished, nearly eight million dollars had been raised and spent in spite of the inveterate skepticism of the financiers of the day, four different kinds of cable totaling 5500 miles had been invented and actually tried in four separate attempts, four different ships had been used, each with specially de-

vised machinery for laying the cable, and four thousand miles of broken cable had been lost at the bottom of the ocean. But the herculean deed was done. Field had kept obstinately to his grand purpose, but had varied his tactics and devised new expedients in an astonishingly fertile way. Not the least impressive part of this saga of the human intellect and will is the fact that, although he was desperately seasick whenever he put off from the shore, Field crossed the Atlantic seventy-four times in the course of his enterprise!

THE VALUE OF ERRORS

Errors can then be cut down and solutions otherwise impossible reached by keeping a flexible mind which knows when to change its tactics. Apparently, however, mistakes and false leads can never be eliminated altogether. Is not this a very wasteful provision of nature, to arrange that practically all thinking and, for that matter, all learning involves doing a thing the wrong way before we can do it right? Is there a divine necessity in man to waste his time by thinking wrong? Things in nature that are at first sight useless often turn out to have their function. The rise of bodily temperature which physicians used to work so hard to prevent is now known to be of great benefit in certain diseases. Physical pain, which seems at first sight to be an unnecessary last straw in the difficulties of life, is often a valuable danger signal without which lives would be lost. Has Nature made a mistake when she provided that we generally think falsely before we think correctly?

Once more we may go to the rat for instruction. Young men and women, when they watch the rat running the maze, often express the same bright idea. "These animals," they say, "choose the wrong turnings at first, and it takes them quite a while to correct their mistakes. In fact, some of them never correct their mistakes entirely, but always take a bow, so to speak, at a wrong passage where they have once had trouble. Now, would it not be better to prevent the rats from making the mistake in the first place? Could we not teach them the correct path in half the time?"

During the fifteen years or so that I have been doing these things, my answer has always been the same. It is the experimental answer.

"Go ahead and try it. Take a couple of animals, and see that they make no mistakes. Then remove your guidance, and see what you will find."

Some try, and some do not bother. On a number of these occasions the wrong paths have been made impassable by blocks of wood at the entrance, or even by the experimenter's hand placed in such a position that it barred the way. After the animals have learned to run straight through for their food without sniffing at the hand or the block which bars them off from the unexplored part of the maze, the obstructions are removed.

The same thing always happens. *The animal now has to relearn the maze.* His total time, from start to finish, that is, from being first placed in the maze to the time when he runs through at top speed without any errors, is often greater than if he had not been given the well-intentioned help of those who wanted to save him time.

There is no royal road to learning, even for the rat.

The experiment has been performed, with many variations, by Carr of Chicago and his pupils, who have used both rats and human beings. Different methods of barring off the rats from the blind alleys were used. In some cases blocks were placed at the entrances, as in the experiments already described. In others glass partitions were put up so that the animal could see but not enter the blind. Some were led through by a kind of dog collar and leash. Human beings were barred off in what is called the "stylus" maze, where a blindfolded subject feels his way through with a pencil tip. Sometimes they were told not to enter certain passages. For rats and men the general results were the same. The assisted trials were not of themselves sufficient to produce learning.

It is true that guidance did help to the extent that assisted trials were better than no trials at all. But after the guidance was removed, human beings seemed to be under a kind of compulsion to explore the primrose paths of error. Professor Carr states that nobody learned the maze during the guided trials, and that too much guidance was actually detrimental. "A certain number of errors," he says, "must be made and eliminated before the subject is ever able to run the maze correctly. Correct modes of response are established in part by learning what not to do." *

Errors, then, have their uses, and are not unfortunate legacies from earlier evolutionary times. They apparently help to fixate correct action and correct thought at least in certain cases. This time an old belief is justified. We may learn much from our mistakes.

* H. A. Carr: *Psychology, A Study of Mental Activity.* New York: Longmans, 1925, p. 98.

Meanwhile, the series of experiments at the Chicago laboratory seems to be of capital importance, if one can apply it to the education of children. Children should apparently be allowed to make their own mistakes: this will help them in their learning and thinking. Too much feeding with the spoon, whether at the table, in the classroom or the playground, is bad, for this among many other reasons. Experiments on children seem to confirm this.

It has been said that the man who never makes mistakes never made anything else. The statement apparently has sound psychological support. Lord Bacon tells us that "Truth comes out of error much more readily than it comes out of confusion."

HOW OUR TRIALS ARE GROUPED

Some psychologists have thought that they have detected a regular sequence in thinking-trials. For instance, a British worker, Cox, tested people by requiring them to assemble the separated parts of a lampholder. He found that they looked over the field, tried the parts mentally, and finally tried to fit parts together with their hands, a process which made the problem clearer for them. Often the problem was solved by this time. If not, they began an active search for the solution in the light of what had been discovered. Most of the work done on this problem was reasonable, not sheer fiddling as is demanded by the trial and error *theory*.

Although in this kind of mechanical problem the procedure showed a certain kind of regularity or law, in most other cases no such law is discoverable. Each thinker may

be a law unto himself, and may even change his own law from time to time. Often mental and physical trial and error appear alternately. No general rule can be given.

In much of the most difficult thinking we do, for example scientific research, trials are grouped together under what are called *hypotheses*. These hypotheses are the scaffolding of scientific thinking. They are provisional ideas, which account for what is known, and serve as a basis for further inquiry which may prove or disprove the hypothesis. It is the mark of a competent scientist that he never makes hypotheses which cannot be tested by experiment.

Thus the great Einstein saw that the results of certain experiments concerning the speed of light could be explained by assuming that the idea of a single, isolated moving object is meaningless. Nature always shows us, he said in effect, movement between at least two objects. Working with this assumption, which is not nearly as simple as it looks, he found that in most cases his new way of looking at things did not make enough difference to be detected under ordinary conditions. But in certain very special cases he was able to make predictions which could be verified by experiment. The experiments were made, and Einstein proved to be right. All the world knows that by an extension of the original theory he was able to find the formula which was the basis of that most momentous of all discoveries, for good or ill, . . . the atomic bomb.

Many people before Einstein had claimed that motion is relative. But it was left for this great thinker to put the supposition in such a form that it both explained what was known and could be tested by experiment. And as the dic-

tionary tells us, an experiment *is* a trial, a test by experience.

In Einstein's case the experiments had been made by other people. What he did was to explain them in such a way as to suggest further experiments. In more modest kinds of thinking the thinker often uses hypotheses to group his own trials.

A young woman reports that she lost a five dollar bill. She thought it must be under the blotter on her desk, but it wasn't there. So she started searching madly through books and drawers, becoming more frantic all the time and more untidy. "I soon realized that I was getting nowhere, so I sat down and thought logically where a person might have left a bill. In one of my books, of course!" So she began a systematic search of the books she had been reading and found the missing money in a copy of *Treasure Island*.

In a way, she used the same fundamental method of thinking as did Einstein, except that she preceded it by haphazard trials. She made a hypothesis ("the money is in a book"), which could be put to the test of experience, and grouped her trials in accordance with it. If experience had proved her hypothesis false, she would have had to make another. The lady might, for instance, have left her money in a suit which had been sent to the cleaner's. In this case she would have had to start another group of trials.

According to some experimenters, animals also use hypotheses. A young scientist, Krechevsky, gave a group of rats an insoluble problem, and claimed that although they made many different trials these were not entirely unorganized, chance affairs, but were grouped according to

simple hypotheses. Thus an animal might adopt a habit of going to the right, and then change over and go consistently to the left. Or he might try right and left alternately. When he abandoned one "hypothesis," he did so suddenly, just as a human being does. Krechevsky's results were obtained not by casually looking at the animal as it worked but by a mathematical analysis which showed that these consistent groups of trials could not have arisen by chance. It is fair to say that many psychologists have questioned these findings; but Krechevsky's results do fall in line with the newer idea that the animal is not so stupid after all!

The stages of thought have been grouped by other workers in still other ways. One of the best known is the grouping proposed by Graham Wallas in his book, *The Art of Thought*.* He distinguishes four stages: preparation, which includes the stage during which the problem is being investigated; incubation, a period in which a man unconsciously mulls over the problem; illumination, when the happy idea suddenly flashes on him; and verification, when the idea is tested and made more exact. Instances have been given in this chapter of what Wallas calls illumination. For a full discussion the reader is referred to Wallas' own inimitable account.

This chapter has shown that thinking proceeds by a multitude of trials, or false starts, which are nevertheless not enough to explain how we reach a conclusion. There must be some further principle by which the thinker decides what to accept and what to reject. Trial and error is probably found wherever life is found, and at least in the

* London: Jonathan Cape, 1926, chapter 4.

higher animals and in man it often helps to fix the correct solution. Human thinkers and perhaps even animals group their trials into lines of thought and action, or hypotheses, of which a number may be tried before the correct one is discovered.

The course of true thought never did run smooth!

Rules: Maier's rules for reasoning are worth repeating. They are: (1) Locate a difficulty and try to overcome it. If you fail, get it completely out of your mind and seek an entirely different difficulty.

(2) Do not be a creature of habit and stay in a rut. Keep your mind open for new meanings.

(3) Keep your mind open for new combinations and do not waste your time on unsuccessful attempts.

Remember that Maier gave a twenty-minute period of instruction on these rules, and they helped enormously.

You may add to Maier's rules:

(4) Don't be afraid to make mistakes. All thinkers make them.

5. THE UNITY OF THOUGHT

THE unity of thought, already mentioned, is the crowning unity of the body. It is the climax of a process essential to all life, one which begins at the microscopic moment of conception and ends only with death. It is thus rooted to the very fiber of our existence.

THE HUMAN METROPOLIS

Imagine a city of a million people, each living his own life, pursuing his own special business, born and dying separately. Each individual has his own special job. There are transport specialists, news experts, experts in food preparation, experts of many kinds down to the lowly individuals who dispose of a city's refuse.

Quite an ordinary affair, you think. There are a dozen such cities in North and South America alone. But this city is different. It is completely and absolutely disciplined. Each individual in it totally submerges his work and his efforts to the good of the whole. During danger and during the ordinary pursuits of the day it literally moves as one man. It is not two minds with but a single thought, it is a city with a single mind in every thing it does.

An impossible, utopian dream, is it not?

But, reader, that city is yourself and myself. And, as the man in the street might put it, that *isn't the half of it!*

You are an individual person, living your own single life, suffering, rejoicing, with your own sorrows and joys, your duties, your legal rights and your own conscious experience, your own thoughts. But science, that is to say, biological science, sees more than this. It sees countless individual, separate lives within you. Each of these individuals leads its own life. It fends for itself, manages itself, breathes for itself, feeds itself. It is "separately born and destined separately to die." * It does everything that science tells us a thing must do to live.

There are within us, by estimate, a thousand million million separately living cells, microscopic in size, each helped by and each helping in its turn towards the common life of the whole. A million billion by the American reckoning, a thousand billion by Sir Charles Sherrington's British method of reckoning it. There are a hundred and forty million people in the United States of America. There are over seven million times as many separate lives in your body and mine. There are two thousand million people today alive on the earth. There are five hundred thousand times as many separate lives in a human body.

How does this gigantic corporate state control its lowly, subvisible, quietly living and often quietly dying members, so that these countless citizens act as one man? This is the problem of unity, of integration, the process by which diverse parts are combined into a single working whole. It

* Sir Charles Sherrington. The reader of his volume, *Man on his Nature*, Macmillan, 1941, will recognize my indebtedness to that truly remarkable book.

is one of the basic features of thought, as it is of all living activity. It will now be treated more fully.

We begin our lives as a unity, a solitary fertilized egg. We develop by dividing and further dividing, each division bringing new, individual cells, the whole remaining a unity still. The cells specialize incredibly, forming bones, the living scaffoldings; forming receptors, whose special job months later will be to register disturbances from without the total mass; muscles, whose business is to move the whole body around; the digestive tract to transform substance from without into chemicals needed by the stupendous whole. During all this development, the parts grow up as a single harmony. The diverse processes have been combined into a working whole with a precision that is unbelievable. There are many hundreds of co-ordinated operations.*

After about forty-five divisions of the original cell, the child is ready to be born. Up to the present, unification has apparently proceeded mainly through chemical means, though pressure of one part on another seems to be important also. Chemical unification still operates after birth, through the glands and other ways. But the main task of unity has gradually been handed over to the nervous system.

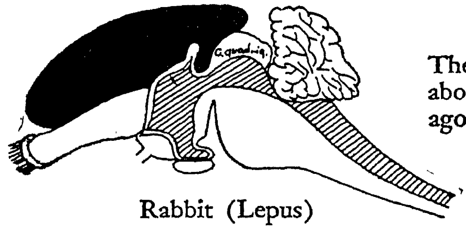
As far as science knows, there is no thought without brain, though the brain apparently needs the other parts of the body before it can do its work. The thinking brain, what Sherrington calls the "roof-brain," is the newest part

* A biological colleague, Dr. Gleb Krotkov, reminds me that there are some twenty parts of the human body that have no present use but are survivals. The appendix is one. These are the biological playboys, living on their ancestors' work.

The right half only of the brain is shown; the "roof-brain" is marked in black.

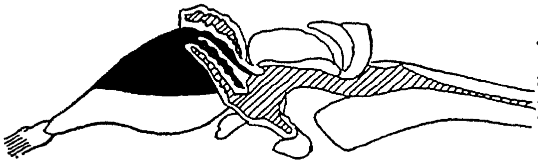
Man (Homo)

Man appeared about 1,000,000 years ago.



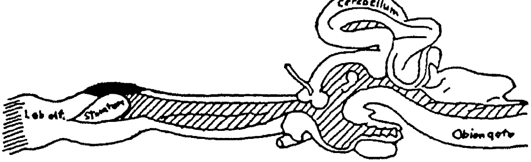
Rabbit (Lepus)

The rabbit appeared about 20,000,000 years ago.



Lizard (Varanus)

The lizard came about 250,000,000 years ago.



Shark (Chimaera)

The shark came about 300,000,000 years ago.

HOW WE GOT OUR BRAIN

The diagram at the left shows step by step the growth of the human "roof-brain" (as Sir Charles Sherrington calls it), which is composed of an outer layer or cortex of nerve cells, together with connecting fibers. It is the special development of the "roof-brain" which enables us to behave like human beings. 300,000,000 years ago, the geologists tell us, the shark appeared, with a mere button of this structure that was to shake the world. Some have even denied that this button is genuine roof-brain. Slightly later, as these periods go, came the lizard, with an appreciable growth. Much later came the rabbit, with an improved development. Perhaps a million years ago the earliest man appeared, *though his cerebral development would at first be considerably smaller than that shown in the top figure.* It is important to realize that human reasoning is only one of the things our brain development has made possible for us. Human speech is another. A third, perhaps most important, is a greatly increased control over the crude, automatic, "unthinking" behavior that is organized through the lower centers. Without this "inhibitory" function of our human brain, human civilization would be impossible. Since the days of the shark, the old part of the brain has not changed essentially. The human roof-brain merely covers up structures that in their essential features are shark-old. It is thus true that *you have a shark in the basement.* The diagrams of the four types of brain are by Edinger, and were reprinted by Koffka. The approximate dates of their appearance were given me by my geological colleague, Dr. Bruce Rose.

of the nervous system, dating in its human form less than a million years. Some say it is even newer. In any case, it is the parvenu, the *nouveau riche* of the nervous system, though it has poor relations among the animals.

A nerve is yet another cell, a separate life within the larger life, which has been built up for the special job of communicating between the different regions of the total living mass. By the time a fish like the shark had appeared in the waters under the earth, a pretty good nervous system had arisen. In all real essentials, with but minor changes through the ages, the shark brain is with us yet. You and I have a shark brain hidden away in the recesses of our skull.

Looking at the history of the last forty years, one cannot feel surprised!

As Nature added her improvements through the ages, the shark-brain gradually acquired an annex, a roof, through which higher things than shark life began to be possible. Even in the shark, the beginnings of such a roof may perhaps be seen, though some have doubted it. Little by little the roof grew greater and greater, through the lizard, the rabbit, the dog and the chimpanzee, until in the massive human structure it now flows over and round the sides ("like a pie-crust over the sides of the dish," a colleague of mine once said!) and even forces itself at places into great wrinkles, so as to give itself more room. The organ of thought and of civilization has been born. Its name is the *cortex* of the brain.

New brain and old brain, the whole mass is made of nerves, and we have just seen that the work of the nerve is to communicate between the parts of the great cell-mass.

By this communication, unity is effected. The old brain itself does a competent enough job of integration. A shark is no mean antagonist in the water, even though we with our superior nervous equipment are able to keep it away with evil-tasting chemicals. A dog without its bit of new brain can stand upright, run upstairs, hold off the ground a foot that has been hurt and run on the other three. But he cannot answer his name or bring in the sheep when he is told to do so. It is through the roof-brain, the cortex, that the dog on the farm is able to do these things and most of the other things he has learned.

THE BOY AND THE WAITRESS SOLVE THEIR PROBLEMS

A young man writes: "When I was about eleven years old and could not swim, I was lying on the beach one day at our country cottage. Suddenly, I heard shouting from the water. I saw that my young brother had fallen into the water and knew he could not swim either. I was supposed to be minding him. He was holding to the canoe and calling out. I ran frantically up and down the sand, knowing my parents were away. I rushed into the water, but was soon forced back. It was too deep for me. A breeze had come up and was blowing my brother away from shore. Then I caught sight of the boathouse at the next cottage. Calling out that I was coming, I rushed to the boathouse, took out the skiff and rowed to my brother, who had blown nearly fifty yards from shore. We came in, towing the canoe." He adds: "We had a hard time explaining to

our parents how we lost the paddle. I learned to swim after that."

Here the boy first saw a set of scattered objects: the boat, the brother, the shore, his own cottage, the next cottage, the neighbor's boathouse. "Raging more wilde than is this franticke sea," he is distracted (which is "pulled in different directions") by all of these. Then something happens and the whole thing is seen as a unity. The boathouse leads to the skiff, which leads across the impassable water, to the boy hanging on to the canoe. He now "sees," we rightly say, a path across the sand to the boathouse to the skiff (in imagination), across the water to his brother.

It is the cortex of the brain that brought about this additional piece of unification. Before the brain did this piece of work the boy was still acting as a unity . . . his heart was pumping blood through the body, his nervous centers were minding the intricate process of "running up and down the sand." But the body was not able to function in a way adequate to the situation until the cortex had brought a fresh unity into the world as the boy saw it.

Thus the cortex serves as a clearinghouse for our senses, reducing their often contradictory, chaotic tidings to a workable form, like a good secretary digesting the day's correspondence, so that a workable single plan of action can be made. It is the "ganglion [co-ordinating center] of the distance receptors." Perception and thought fuse together in an undistinguishable unity. It would be futile to speculate where the one ends and the other begins. They are each part of the great unity effected by the roof-brain.

A waitress in an exclusive summer hotel reports: "*The guests were never wrong*. Very often, however, they would

add to their written orders verbal instructions which were difficult to remember. One gentleman handed me an order for two steaks, saying: 'One well done.' As I came out of the hurry and bustle of the kitchen I thought, 'Lord, I forgot the one well done!' I thought I would go back to the kitchen, but the head waiter would see me, the head chef would object to the waste, the guests would complain of poor service. If I asked who wanted the special steak I would call attention to the cooking, and the head waiter would be called. So with as much assurance as I could, I said 'One well done.' The lady took it and never questioned the cooking. I received a dollar tip."

The waitress might have let the situation get the better of her. She might have rushed back to the kitchen, back again to the table, blurted out, "Who wanted it well done?", run away from the threatening head waiter and so on. In that case we would say she had "lost her head," though it would be more correct to say she had lost her cortex. Instead, she used her new-fangled brain to see and use a single plan which took the alternatives into account by avoiding them both!

THE MARVEL THAT IS THE HUMAN BRAIN

What kind of thing is this roof-brain, this worker of marvels, this newest and most stupendous of the inventions of nature? We saw that it is made up of nerve cells, which can do nothing but transmit disturbances of an electrical and chemical nature. These disturbances are transmitted

from one nerve cell to the next over junctions which seem to have important properties. The cells apparently act not as individuals but in blocks or patterns, probably involving the whole mighty organization. A small part of them, something less than a quarter, is given over to one or other special function related to the sense organs, so that we may speak of the visual area, the area for hearing, the motor area, and so on; but most of them appear to be unrelated to such special functions. While we are awake and to some extent when we are asleep, many, at least, apparently fire themselves off automatically several times a second. These and a few similar facts, which to be sure have in many cases been worked out in great detail, are about all that we know in particular of the working of this great mechanism.

A few figures given by the neurologist Herrick will give an idea of the complexity of this organ of integration which nature has put at our disposal.

"It has been estimated that the human cerebral cortex contains 14,000,000,000 nerve cells, each of which is connected by branching nerve fibers with hundreds of other cells in inconceivable complexity. If a million cortical cells were connected one with another in groups of only two in all possible combinations, the number of different patterns of connection would be expressed by 10 with an exponent of many thousands. *This, of course, is not the actual structure*, but the illustration may serve to impress on us the fact that the known structure of the cortex provides for momentarily shifting patterns of nervous conduction in variety that is practically unlimited." *

* Communicated by Dr. Herrick in personal correspondence, with permission to quote.

The figure indicated by Herrick is truly past imagining. We are accustomed to speak of the astronomers' figures with some awe at the vastnesses they display. Yet the distance of the nearest fixed star from the earth, *if transformed into feet*, would be something like ten with an exponent of seventeen (10^{17}). It is a mere bagatelle, a nothing to the fabulous number hinted by Herrick. It would not be noticed in any measurement of the latter that could be made. We must try again. It has been estimated that the number of atoms in the entire visible universe—earth, sun, stars, milky way and all—is 10^{66}. In order to reach Herrick's number we should require the *atoms* in many thousands of universes. One can only exclaim, with the poet Keats,

"Listen awhile, ye nations, and be dumb."

After these figures the feats of the human mind, remarkable though they are, must come as an apparent anticlimax. Do we use this machine for such trivial things as writing a letter, thinking up an excuse for staying home on Sunday, or solving a quadratic equation? Do we even use it for searching out the law of gravitation or discovering the principle of vaccination? If we do, must we not feel with another poet this time that:

"The mountains are in labour, the silly mouse is born!"

Surely for such a mechanism any human activity is grossly overpowered.

"Have you a good cab?" asked the highly dressed young playboy of the Victorian cabby.

"Yes, Sir."

"A very good cab?"

"Yes, Sir."

"A really first-class cab?"

"Yes, Sir."

"Then dwive me next door!"

With such a machine, the highest flights of the human intellect, the most searching works of our men of letters, the greatest compositions of our musicians, seem like driving next door. And yet the anticlimax is only apparent. The psychologist sees the development of mind from the dim struggling of the one celled amoeba; he looks from the sea-anemone learning with its simple nervous system to avoid a disturbance, to the primitive memory of a fish, to the ponderous gropings of a turtle, the enormously more complex learning of those aristocrats, the cat and the dog, and the completely astonishing performance of those super-aristocrats, the chimpanzee and the gorilla. He follows all this step by step upwards and into more complex human regions. And he is forced into startled amazement at the everyday activities of the man in the street. When he sees a class of boys learning to solve quadratic equations he feels like Doctor Johnson who, watching the poodle walk, remarked that the wonder was not that the dog did it so badly but that he was able to do it at all!

To take a piece of paper and figure out the cost of a visit a hundred miles away; to direct a person to the hospital, "take the Bay Street car, get off at College Street and walk two blocks west"; to listen to a car, as my garage man did the other day and say: "It sounds to me as though the valves need doing"—these are activities which seem positively superhuman to one who has studied behavior and nervous system in their simpler forms. It is indeed hard for

the psychologist to believe that they do take place. A young man who had spent his life studying the psychology of the simpler forms of life once said that he did not believe that anybody really could do a sum in arithmetic! I know exactly how he felt. And yet we know that human beings do all these and many more difficult things every day.

It is the human cortex that does them, that unparalleled contrivance of nature. It is custom alone that has dulled our wonder at its amazing performance.

HOW THINKING FASHIONS A UNITY

I happen to have before me a textbook of school physics. It well shows the work of integration carried out by our thought. Let us imagine Johnny Smith faced with this formidable-looking problem, which I find at the end of the book. It does indeed look rather difficult for those of us who have left our physics years behind at school. But I will ask the reader to read it through in order to see the nature of the truly prodigious feat of integration which Johnny Smith is accomplishing in a hurry so he may be allowed to get out into the spring sunshine. Johnny will be perhaps eighteen, or even sixteen if he is very bright.

The cylinder of a steam engine has an internal diameter of 5.6 inches, and the average pressure of the steam during the stroke is 80 pounds per square inch. If the length of the stroke is 10 inches, find the work done per stroke in foot pounds.

To relieve the reader's mind, I will say at once that the "answer" will be given later on. Remember that there are

hundreds of thousands of eighteen-year-old boys and girls who are able to solve this and equally difficult problems, tens of thousands whose brain can perform much more difficult feats, and thousands of adults, of the race known as scientists, to whom such a question would be quite literally child's play.

What is Johnny doing?

Well, first of all he has to read the question. Reading, that's easy!

Is it so easy?

Johnny's eyes do not run straight along the lines like a snail. They hop inelegantly, like a flea, each time pausing for perhaps a quarter of a second. Altogether he will make between twenty-five and thirty pauses, though there may be more since he must read carefully. During the time his eyes are moving he sees very little. The reading is all done while the eyes are at rest.

There are a hundred and ninety-four letters and figures in the four lines of print, so that each time Johnny's eye pauses for a quarter of a second he must cover six letters. We know that reading is not done letter by letter, but by words and blocks of words. It takes no longer to read a short word than a single letter. Still, the letters have to be taken into account. They have to be integrated into words, and the words into sentences. By the time Johnny is finished reading, which will be seven or eight seconds he has "got the problem in his mind," which means that he understands the four separate sentences, and has combined them into the single idea of the problem and what he is required to do.

In this "problem" a hundred and ninety-four letters

make up forty-seven words.* These make four sentences, and these the single problem. But the letters do not make the words nor the words the sentences. It is Johnny's cortex that does the making! Already an integration of an integration of an integration! Can the boy's mind do it? We know it can, and that it can further "grasp the ideas" involved.

Only when this tremendous job has been done can the real work begin. Johnny would be pleased enough if he could get away with just reading and understanding the problem. So he starts his calculations. Perhaps four or five lines of figures are written, with calculations at the side, and finally the "correct" answer appears.

It is 1642 2/3, and he will probably add "foot pounds," since that was called for in the question.

During all this time he has kept going an intricate mental process involving multiplication and division, themselves involving addition and subtraction, the whole forming a thought-unity of a very complex kind. Out of the original hundred and ninety-four letters this complicated, unified process arises, issuing finally in six figures. For that matter, it might have been one figure. This is the integrative job that the cortex has done, reducing first the perceptions into wholes, tier upon tier, grasping and combining "ideas" and combining these again, following with complex processes until a single solution has been reached, which is written in six digits!

This is a simple problem in high school physics! The ridiculous mouse has been born in six figures! In point of

* Counting the figures as one word. Of course the figures for the reading are only approximate, and we are assuming that Johnny is a "good" reader.

fact, it takes more than mountains to bring forth a mouse—it has cost nature millions of years and the lives of countless lowly creatures! Maybe the mouse is not so ridiculous after all!

Professor N. R. F. Maier believes that the fundamental thing in reasoning is such a process of integration, in which a person combines past experiences. In support of this, he has done some beautiful experiments. They seem to show that children manifest a sudden spurt of power at about six years of age, with a regular increase of ability after that. Before the age of six, the children rarely seem able to combine past experiences in the manner which his experiment called for. (He used a kind of maze.)

THINKING AND LOGIC

The integrative work of thought is well illustrated by certain rules of elementary logic. Here, in order to clear away any confusion, a word must be said about the difference between logic and the psychology of thinking. The two were frequently confused until about a generation ago.

A man is sitting in his office. "It's a snowy day," he thinks, "and the train will be late." At the same time we may suppose he has mental pictures of the railway station, of the train coming in, and of the person he is to meet. Half or fully formed words come to his mind We also know that there are slight contractions of the speech and other muscles. (This fact has already been mentioned, and will be the subject of a later chapter.)

A woman is sitting in her home. She is thinking: "It's a

snowy day, and the train will probably be late." Mental pictures are appearing in *her* mind also. She sees the engineer in the locomotive cab, the cab covered with snow, a tired man getting down from the cab and walking wearily along the platform. She is the engineer's wife. She takes down the telephone and dials a number.

"John," she says. "Is number forty-seven on time?"

"Right on the dot," is the answer.

"I thought it would be late on such a snowy day."

John is busy. "I don't care what you thought," he says, "the train's on time," and hangs up.

John does not know it, but he has neatly expressed the difference between logic and psychology. The business man and the engineer's wife both thought about the same thing. They did it in two different ways. *The logic of the case* was unaltered by how or what either of them thought. Snowy weather does not necessarily mean a late train!

External events are independent of what any particular person thinks. Logic is interested in the fact that, given certain events, others must be so. Psychology is interested in the way a particular person comes to a given conclusion, right or wrong, with or without imagery, muscular contractions, and so on.

A visitor to a prison, on seeing a convict, said,

> "Brothers and sisters have I none
> But this man's father was my father's son."

When this riddle was given to a subject in the laboratory, he reported seeing a mental image of the warden taking the visitor around, with a picture of a host of brothers and sisters "round" the visitor. These disappeared, leaving the warden alone with the other two. Then the subject im-

mediately "saw" and said the answer, which is that the convict was the visitor's son.

Another subject reported no mental imagery but began to say out loud: "If the convict's father was his father's son, the visitor and the convict's father must be brothers. The convict is the visitor's nephew. No, that won't do, because he has no brothers and sisters." There was a pause . . . "The convict must be his own son."

Logic is interested in the fact that the two statements in the rhyme *imply* the further statement, "It is his son." The psychology of reasoning is interested in the different ways in which these two particular people reach the conclusion. It is striking to observe people in the laboratory using very different methods to obtain the same answer to such problems. The difference is particularly marked in the number and amount of mental pictures or imagery used.* The solution of the riddle involves a complex combination, first of speech, so that the solver can understand the riddle, and then of the "ideas" in the problem. The answer comes as the result of these integrations, and sums them all up.

Then again there is the *syllogism*, famous for two thousand years, which learned men once bullied people into believing to be one of the ways by which everybody ought to think. Blood has been shed over the syllogism!

I heard the following conversation one day at my garage. It would have delighted old Aristotle.

Tiresome Customer: "How does my starter work?"

Foreman, in some impatience: "Your car is a '42 Plymouth. All '42 Plymouths have manually operated starters. Yours is manually operated."

* Some would say that this is the *only* difference, but this seems doubtful to the writer.

Little though he thought it, the foreman was speaking in a perfect syllogistic form! (Like the gentleman in the play who was astonished that he had been speaking prose all his life!)

Instances of this form are hard to find in actual life. I do not remember ever observing a person in the laboratory use it to solve a problem. It is the method by which a general fact is stated, and is followed by a particular fact coming under the general rule, so that the "conclusion" follows.

The logicians believed that they had found one of the important ways in which human beings "ought" to think. What they had really found was a convenient way of classifying the connections between facts. Lives were lost over the confusion!

However when we do think in this way, by combining a general with a particular premise to draw a conclusion, the brain must of course perform an integrative function. It is possible to translate much of our thinking into these terms, although the method is not a natural one for most human beings.

A FINAL EXAMPLE

When a modern scientist uses a formula, he is using the integrative powers of the human brain to an extent probably unparalleled in the history of thought. By patient observation of natural facts his predecessors have hammered out certain "laws" of nature. These laws are thus the product of extremely complex processes of integration, for they combine into a few symbols a tremendous sweep of natural events. Newton's law of gravitation did exactly

this. It stated that the apple was attracted to the ground in the same way as the moon was attracted to the earth, the earth and the other planets to the sun, and *every particle of matter in the universe to every other particle.* It stated all this by the use of a few symbols written on paper. There are today five symbols on which the fate of the human race hangs as by a thread. They are incomparably the most important symbols in the world. They were put together as a result of one of the most startling feats of integration that the human mind has ever achieved. Like Newton's law and, for that matter, all other laws of physics, they combine statements about every particle of matter in the universe. But they surpass Newton's law in that they rest upon the exact and painstaking work of hundreds of scientists in dozens of laboratories over generations, and in all parts of the world. From all these laborious niceties a human mind has distilled a single statement, so simple that a twelve year old child could be taught to understand it.

Conceivably, as the result, the very earth on which we stand may one day dissolve into fire and be scattered into dust along its orbit round the sun! The statement is: $E = mc^2$, the formula devised by Einstein to show the amount of energy which may be liberated from matter, and on which the force of the explosion of the atomic bomb depends.

Who would call this an anticlimax to the working of the great mechanism of the human brain?

Note: Translated, the formula means that the amount of energy which may be liberated from matter, given of course the proper means, is equal to the mass in question times the square of the velocity of light. We have been told that the possible danger is that the dissolution of matter may spread over the whole earth, like a fire.

6. THE GUIDANCE OF THOUGHT

THIS chapter deals with the problem of concentration and its failure. A sub-heading might be: WANTED, EXPERIMENTS. For the psychologist is able to make cures, but when he does he often has to neglect the theory he teaches in the classroom, as well as the apparent results of his own experiments in the laboratory. He badly needs more experiments to clear the whole thing up.

I know a young man who is putting himself through college. He is serious about getting a degree, but when he sits down in the evening his thoughts run on home, vacation, girls, football, everything but the open textbook before him. There is another who is starting with his father as a plumber. In the middle of a job his father calls out to him, "What are you doing, son, dreaming? Get that pipe screwed up." As his mother says, the boy doesn't concentrate.

By contrast, here is a third young man who goes at everything with a kind of quiet energy, never wastes a moment on unnecessary matters, is in demand for all kinds of organizations because he goes straight to the point and gets what he wants. When he takes his training as a lawyer he works with great concentration, never allowing noises or other disturbances to interfere with what he is doing,

sits in courts when he can, and follows the cases with absorbed interest.

What has this young man that the other two lack? What keeps his thoughts to the point, while those of the other two wander?

It is a difficult problem since it touches on so many others. It is all the more difficult because, to a good many "normal" people, it hardly seems to be a problem at all. When a normal person is thinking out, as I was the other day, how to get a long bookshelf upstairs into his study, he takes it for granted that he does not start saying to himself, "Four times nine is thirty-six, the last time I took the car out there was a rattle in it, a Canadian dollar bill is green." If you ask him he will tell you that of course he does not do anything so silly. Nevertheless, this is exactly the kind of the thing that the man who cannot "concentrate" finds himself doing.

Suppose that I was able to dump a hundred thousand or so bricks out of some colossal bulldozer half a mile up in the air, and found that they fell in exactly the right way to make a smoothly paved road from the highway along the side road, over the bridge, through the gates, and a hundred and fifty yards over the rocks to my country cottage. That would be a surprising outcome.

There are, probably, more possible "ideas" as I work towards the goal in a problem than the bricks I would need to do this quarter mile of paving. Yet the thoughts do go more or less in the right direction, while the bricks would fall helter-skelter without any relation to the goal.

This, then, is the problem. *What keeps our ordinary thinking more or less on the track, so that while we do*

make mistakes, they are generally relevant ones? What makes our thoughts follow each other in an orderly way towards the goal? In short, what directs our thinking and causes us to concentrate on the problem? It is not a new question. As long ago as Greek times, people noticed this remarkable fact of our everyday life.

THE MAN IN THE STREET'S ANSWER

One obvious answer invokes the "association of ideas." The sight of the movers lifting the bookshelf brings to my mind the time when I did get a bookshelf into a room by turning it over the banister. That again brings up the other time when I had to have a large piece of beaver-board turned and tilted to get it upstairs. The one idea brings on the other. All these associated ideas are to the point, and thus it seems my thinking is kept within the proper channels. There are no associations between bookshelves and the time a plane takes to fly from Los Angeles to Toronto, or between stairs and the number of different pickles Mr. Heinz makes. So these irrelevant thoughts do not come.

A competent young friend writes an account of what seems to me a fine piece of detective work. "I once foolishly promised to take a message to a man in Chicago," he says, "knowing only that his name was O'Leary * and that he was in charge of a restaurant. First I consulted the yellow pages of the telephone directory, but without success. Then I called several restaurants at random, again without

* I have changed the name. If there is an O'Leary in charge of a restaurant in this district, this is a pure coincidence.

result. I considered calling the police, and the Chamber of Commerce, but thought they would not welcome such an inquiry. The thought then struck me that O'Leary would probably be found in the Irish section, near the Armour packing houses. The *Traveller's Guide to Chicago* told me there were seventy-two restaurants and confectionery houses in this district. O'Leary would not advertise Chop Suey, nor would he, probably, work in a restaurant with an Italian or Greek name. This left eight possibilities, and when I telephoned these, asking for Mr. O'Leary, I was successful on the third trial."

An excellent solution of what must at first have seemed an almost insoluble problem! It does apparently follow from the association of ideas. From the restaurant came the idea of the classified pages of the telephone directory, because my young friend had doubtless seen lists of restaurants in the back of telephone books. This did not work, so "restaurants" called up the idea of telephones, which he had seen on the counter at various restaurants in the past. The idea of finding a person called the police to mind, O'Leary's Irish name called up the idea of the Irish part of the city, and so on until he got an idea which worked.

This is the "classical" explanation of thinking. In one form or another, it has been put forward by different people for a couple of thousand years. It is usually the explanation given by the intelligent man in the street if you ask him. Said simply, the theory is that if two ideas have occurred together in the past, then one of the pair tends to bring the other with it in the future. "Restaurant" brings "telephone," and so on. Countless experiments have been done on association, and many of them are repeated every

day in laboratories the world over. Probably the majority of psychologists follow the man in the street and use some form of association to explain thinking, although some modern psychologists would prefer to put the theory in rather different words, and speak of conditioned reflexes.

RATIONAL ACTION AND THE CONDITIONED REFLEX

Most people have heard of the conditioned reflex, such as the Russian scientist Pavlov obtained when he rang a bell before feeding a dog. After twenty or thirty repetitions, the dog's saliva flowed as soon as he heard the bell. The saliva could be observed and measured so that Pavlov did not have to attempt the impossible task of asking the dog what his ideas were!

But, for all that, Pavlov was working with association—association of stimuli, not of ideas. And there are many who have claimed that this kind of association can explain all rational action, just as the men of the last century claimed that association of ideas could explain all thought. And here is a curiosity of science. Experimental psychologists, working in the laboratory during the last fifteen years, have found exactly the same objections to this theory as the philosophers did to the older theory in their grandfathers' time. It is a curiosity because there is no reason to believe that the younger men had any idea that they were following in their grandfathers' footsteps.

I will take a single example; it is one of half a dozen cases where the modern experimenter with his exact meth-

ods has come to the same conclusion as the philosophers sitting in their easy chairs sixty years ago. During the later years of the nineteenth and the beginning of the twentieth centuries, a cloistered philosopher, F. H. Bradley, lived at Merton College in Oxford. Bradley was all against the theory of the association of ideas. Among his many arguments, and he was a doughty man with his pen, he stated that associated ideas are never reproduced exactly from the past. They are changed by thought to suit the context in which they occur. So that association is not of itself sufficient to explain thought. There must be some additional factor which brings about this change.

Bradley was a great thinker and he disliked experimental psychology. But it was his fortune that fifty or so years later, this argument of his was strikingly confirmed by experiment.

If a person's hand receives an electric shock, he will jerk the hand up. If now a musical note is sounded shortly before the shock comes (about half a second is the best interval), and this is repeated from ten to thirty times, he will associate the bell with the shock. When the note sounds, and before he gets the shock, up comes the hand! But accurate measurement shows that the movement which follows the warning bell is not identical with the one that follows the actual shock. The hand goes just far enough to avoid the shock and generally not much farther. If, again, a puff of air is directed at a man's eye, he blinks the lid. In an experiment of Hilgard's, an association was formed between such a puff of air and a light which preceded it. In other words, the person was "conditioned" to blink when the light appeared. Hilgard found that the

eyelid moved much less after the light than after the actual puff of air. He used a beautiful photographic method by which the extent of the movement could be precisely measured, as could the time taken for movement.

Perhaps the most interesting set of experiments was done on the psychologist's faithful friend, the white rat, by Dr. Warner, who caused rats to jump over a fence, again by an electric shock. He then sounded a buzzer a number of times before this happened. The rats duly learned to jump when they heard the buzzer. But the jumps were quite different. The sound was followed by "a smooth, neat . . . movement, just high enough to clear the fence." The jump following the actual shock was a jerky ungraceful scramble, during which the animal pulled one or more of his feet rapidly off the ground.

You will perhaps feel that these experiments are made on trivial activities. What have physical jerks, blinking eyes, shuffling rats, to do with thinking? Bradley would have had great scorn for them. But remember that in order to understand, science must first analyze. In order to know what happens when complex human activity is produced by association, we must break the activity down into its simplest possible form, in human being or animal. When this is done, the weight of experimental evidence shows that associated action is by no means an exact copy of the original, but is changed, generally to suit the new context in which it occurs.

But this was exactly what Bradley had said fifty years before, about thought and the association of ideas. Bradley had his feet on his study mantelpiece, the experimentalists had theirs very much on the ground! Other criticisms made

by Bradley and his fellow Victorians have been confirmed in an equally striking manner by experiment.

Thus, when we solve a problem, we cannot explain either our thoughts or our actions solely as a process by which one memory-photograph automatically fishes up another, and this again another, from the past. Philosophers in the nineteenth century and experimenters in the twentieth have maintained that there must be something else present in directed thought and intelligently directed action. Association of ideas or of actions is not enough.

I was recently with a psychiatrist friend of mine as he was going his rounds in a hospital. We approached a gray-haired man, who welcomed us. "Hello, John," said the doctor. "Would you like to show my friend how well educated you are? Won't you do some arithmetic for us?"

"Sure, Doctor." A look of concentration came over his face.

"Well, supposing you had four boxes, each with twenty-two matches inside. How many matches would there be altogether?"

"Four boxes, that would be four boxes and four lids. Boxes must have lids. If the boxes don't have lids, the matches fall out. You can't carry them that way."

"Yes, four boxes and four lids, that's right. But how many matches were there in all the boxes together?"

"Four boxes, that's one, two, three, four." He counted on his fingers. "I had four children, that is, there were four with my wife and myself. My wife's dead; she died yesterday."

"Not yesterday, John; it must have been longer ago than that. How many matches were there?"

"Matches? I certainly will give you a match, Doctor, after all you have done for me." He felt in his pocket for a match, and a look of annoyance passed over his face.

"I don't seem to have a match." (Actually he was not allowed matches.)

"Well, that's just too bad. I'll be seeing you tomorrow, John."

The doctor stepped out into the hall with a sigh of relief.

The "association of ideas" is working in poor John's mind also. Four boxes leads to four altogether. Four boxes leads to four lids, and it is true that if the boxes have no lids the matches will fall out. Four boxes leads also to four in the family, and "family" to John's wife. Matches leads to the familiar request for a match. But there is certainly something missing.

What is it?

Among the many psychologists who have thought they had the answer were the Würzburg group, mentioned in an earlier chapter. They claimed that there are mental direction finders which guide the associations.

MENTAL DIRECTION FINDERS

In his early days, Edison found that he could not receive telegraphic news messages fast enough. So he arranged two old Morse registers in such a way that the dots and dashes were recorded by one machine on a strip of paper. This was placed in the other machine which retransmitted the message at any rate desired. The manager was suspicious of young Edison's extraordinary efficiency and "shook his

head in a troubled sort of way"!

Years later, Edison was experimenting with the telephone. The idea occurred to him, in his own words, "If indentations on paper could be made to give forth again the click of the instrument, why could not the vibrations of a diaphragm [the thin vibrating plate in a telephone] be recorded and similarly reproduced?" *

The thing was tried and it worked! The phonograph had been born.

How would the Würzburg workers have explained what happened?

They would have pointed to Edison's own account in the same article. "It was that same rude automatic recorder that indirectly—yet not by accident but by logical deduction—led me long afterwards to invent the phonograph." * Vibration of the telephone membrane is associated with the vibration of the telegraph needle, which is connected with recording, and *His Master's Voice* is well on its way!

But they would have said that all this could not have happened without the natural direction finders, the determining tendencies as they called them, which kept out the wrong associations and strengthened the right ones. There were many other directions in which Edison's thought could have run. He, himself, states that his mind was filled at the time with theories of sound vibrations and their transmission by diaphragms. But, according to these psychologists, he was kept strictly on the problem by the determining tendencies which admit only those associations headed in the right direction.

Many able modern psychologists believe much the same thing. Instead of determining tendencies, some would em-

* G. A. Lathrop, in *Harper's Magazine*, February, 1890.

ploy a term to which the reader has already been introduced. We saw in Chapter 3 that a human being must be motivated to *undertake* a problem. Many psychologists today believe that the motive has this further job of deciding between the associations which come up during thought.

For instance, Dr. Leeper, a very able experimentalist as well as theorist, placed rats in a tunnel shaped like a T. One arm of the T led to food, the other to water. Sometimes the rats were hungry, sometimes thirsty. In less than three weeks, with five daily trials, hungry rats had learned to take the passage to food, thirsty ones to water, with an accuracy of over 90 per cent. "One of the prime functions of motivation," he says, "would seem to be that of determining which associations or which habits are to be utilized in any particular situation. Everyday observation does seem to indicate that motivation serves this purpose." This is the general conclusion that the Würzburg psychologists reached in their work on human beings. To them goes the credit for first showing that motives were necessary in order to explain how thought keeps to the point. But they did not succeed in showing how the motives worked. It is not hard to see why.

The lady in the stamp booth at my local post office was counting a broken sheet of stamps. I observed her count seven along one side of the rectangular sheet and nine along the other, and then announce, "Sixty-three."

According to the Würzburg theory, all the associations connected with seven have to be cut out except "seven-times-nine." There are dozens of them: Seven days in the week; seven seas; seven-leagued boots; seven and one are eight; and so on, almost forever. If we are to believe the Würzburgers, all these extra associations tend to come into

the lady's mind and have to be pushed back.

It is all very wasteful, and puts the emphasis on the wrong part of the process. It makes her spend most of her mental energy not in the construction of the correct solution but in the destruction of the wrong ones. It makes thinking into a process of intellectual fly swatting! This is certainly not the way we ordinarily think of motives as working.

There was once a man who marked his name on his front door by painting all the rest of the door except the space forming his name. He wasted a lot of paint! There was an Irishman who proposed to make a cannon by taking a hole and pouring some lead round it. These two remind one of the theory that we think by crossing out ninety-nine errors, thus leaving the one correct solution.

The theory of the Würzburg psychologists was in fact based on association, assisted, it is true, by motive or by determining tendencies. Thus it has never really met the criticism of modern psychologists, or, indeed, of the philosophers of sixty years ago. It was a patch sewn on an old garment at a time when critics were calling for a new coat altogether!

Where can we get a new coat? If association with the past does not provide the background for our thought, what does?

THE SURPRISING LEWIN

A rather surprising alternative has been proposed by a very able psychologist, the late Dr. Lewin, who has, how-

ever, not yet succeeded in convincing the majority of psychologists.

As the result of a series of experiments made in Berlin in 1922, Lewin claimed to have shown that one idea *never of itself* brings up another from the past or, if you prefer it, one stimulus *never of itself* brings up a reaction belonging to another with which it has been associated. For example, pairs of syllables were repeated a large number of times over a number of days. A list of syllables was later given to the subject, with instructions to read it and wait. Although some of the repeated words were included in this later list, it was only in exceptional circumstances that they brought up the thought of the associated word, and Lewin had little difficulty in showing that these exceptions illustrated his point. These conclusions have been questioned by the redoubtable Thorndike among others. To be called in question is the fate of all startling experiments, but I do not believe that Lewin's massive array of experiments has ever been really answered.

Now this made a topsy-turvy state of affairs. How topsy-turvy can be seen from the following.

It means that an object *of itself* never reminds you of something else! When the young man in Chicago thought out the way to find O'Leary, the restaurant did not remind him of the yellow pages of the telephone directory, nor the name O'Leary of the Irish section of the city. The vibrations of the telephone-diaphragm did not remind Edison of the telegraph recorder he had devised years ago! The clock striking twelve does not remind the housewife that she has not put the potatoes on to boil!

And, in a train of thought, one idea has no power to

bring up an associated idea!

Thought thus seems to be like a freight train with no couplings between the cars! We know what the engine is. It is the motive which drives us towards the goal. But we do not seem to know what attaches the mental freight cars to each other.

Here again Lewin has proposed a way out which has not yet found favor with all psychologists. In essence it was the solution proposed by Freud, the father of psychoanalysis, in a totally different connection. Since Freud's solution is easier to understand, I will explain it first.

HOW FREUD EXPLAINS THOUGHT

Freud was interested in mentally sick people, and his most important work was done on patients with the less serious mental disorders known as neuroses. (Hysteria is an instance.) As you may know, he also interested himself in dreams and their meaning. Now mentally distressed people often act in a way which, to the outsider, seems "silly," that is to say, out of step with the situation in which they are. Freud claimed that all these apparently senseless activities had their own meaning in relation to the illness. Not only that, but all the apparently trivial, senseless, meaningless actions that normal people such as you and I do, also have their own meaning. They are all the expressions of some kind of a wish which we generally do not admit to ourselves.

In the days of the horse and buggy, my Uncle Harry was courting a beautiful but rather hot-tempered girl. My

uncle was twenty at the time, and was considered a good match. After a good deal of hesitation, he decided one day to put the fateful question. So, in the manner of the time, he went to the jeweler's, purchased a diamond ring for more than he could afford, and placed it in his waistcoat pocket, which had been embroidered, also in the manner of the time, by the lady's own hands. Meanwhile he told her that he had a little present for her, and an important question to ask.

The day came. My uncle went to the stables, where horses were on hire for just such occasions. He did hire a "horse and trap"—the "highest-stepping horse in the town!" Calling for the girl, he drove with her to the North Foreland Tea House. For all this happened by the seaside in the South of England.

Seated in the famous gardens, in an alcove cut off from the world by a hedge of boxwood, my uncle drank tea with his inamorata. Leading subtly to the point, as only he could, he finally put the question. At the same time he said: "And if you will only say *yes*, I have the nicest ring in all the county for you, just the ring for your little finger." So went my uncle's account, many years after.

At which he put his hand into the left hand pocket of the embroidered waistcoat. Puzzled, he put his hand into his right hand pocket, then into his trouser pockets, one after another, and into the side pockets of his coat.

The ring was not there! At which the lady stood up and said she thought it was time she was getting home. It seemed she had promised to do some shopping for her mother!

When he returned to his room, my uncle found the ring on the bureau where he had put it, plush case and all. And he added, when he told me, "*Wasn't I relieved by the way it had all turned out!*"

Now Freud's account of this incident which, in spite of my uncle's known abilities with a story I believe to be true in its main details, is that he had taken the ring out of his pocket by no accident, but as the result of a wish. Although he was smitten by beauty's charms, he did not wish to marry her. Wishes, like murder, will out. This wish expressed itself by the action of removing the ring from harm's way.

Another incident, this time from Freud's own case histories. When Freud was a young man, one of his patients was a hysterical woman, part of whose symptoms were that she constantly babbled words that seemed to make no sense. He had the idea of hypnotizing her, when he found that the symptoms had a definite meaning for her disease. They were the expressions of wishes which, in her normal state, she would not admit to herself.

For Freud, to say that thought works by association would be to put the cart before the horse. The fundamental thing for him is the wish or motive. Past associations and present circumstances are the means by which the wishes find expression or are checked.* Sometimes they may frustrate the wish, sometimes they may help its expression. In any case they are what the wish has to work with, and through. If they change, the expression of the wish will change, while the wish may remain the same. If

* He does make certain exceptions but this is the general drift of his thought.

a boy's consuming desire is to be important, and he finds himself apprenticed to a tailor, his wish may drive him to become the best or the biggest tailor; if he starts out in the army, the same wish may urge him to the top of the military tree. Thus it is that the mentally sick will often weave the newest invention into their delusions. Thirty years ago, the patients in our asylums were complaining that people were looking at them with x-rays. Twenty years ago it was radio that was pestering them. I remember well one patient who had a radio set on his back, where he could not get at it, and through which his enemies were shouting insulting messages at him. Today our mental hospitals are admitting patients who are worried by—you have guessed it!—the atomic bomb.

If we are to believe Freud's explanation in all these cases from my uncle in the tea-garden to the patient afraid of the atomic bomb, it is the human wish or motive that worked out through the environment, and provided the background for thought. The environment does not force itself on the human being by a chance combination of situations as the conditioned reflex and the older association theory demand. If a cure is to be effected, the important thing is first to disentangle the motives. This is probably Freud's most valuable contribution to psychiatry, and is accepted by many psychiatrists who disagree with most other things he has said.

The poet Horace once said:

> "Those who rush over the sea in ships
> Change but their climate, not their heart."

Freud would thoroughly approve of the sentiment.

THE MOTIVE ONCE AGAIN

Lewin gives a very similar explanation of his experiments, though in more technical terms. The shot-gun marriage of two ideas in the past is powerless, he says in effect, to force the one partner to follow the other and thus direct thought. All past experience can do is to provide certain "traces" or tracks, through which motives work themselves out. A streetcar conductor headed in a certain direction must travel along the tracks already laid. They may not lead directly to his destination, but he must use them as they are. According to Lewin, our motives similarly use the tracks laid down for us by past experience, the difference being that the traces are relatively flexible affairs, altering according to certain laws, but still remaining traces, inert channels for our mental energies. Thus our thought is directed *at every step* by motives, which use the tracks provided by our past life, and which are called into being, he believes, when we perceive and accept a problem.

There are many objections and difficulties, and the problem may safely be left to the young experimentalists of the future. One may be certain that they will leave it in a different form from which it finds itself today! If it is permissible to make a guess, it would be that thought will be found to be directed in its broad outlines by motive or needs, in the manner indicated by Lewin and Freud, but that habit or association will also be found to play a minor, though as yet undetermined, part. In any case, Lewin's acute experiments have once more put association very much on the defensive.

If experiment could establish to everybody's satisfaction that motive is largely responsible for directing, as well as for initiating, thought, several difficulties would be cleared up. For instance, the last chapter explained that when a boy completes a classroom problem, the whole process is a unity. Each step is part of a whole, not just a separate operation of adding or subtracting. This seems to require some single thread running through the whole operation. It is much easier to see how this could be provided by a unifying motive, than by a series of step-by-step associations.

It would also be much easier to reconcile fact and theory in the practical problem of concentration. Lack of concentration often goes with a conflict of motives, and often disappears when the conflict is cleared up.

An old sailor in Nova Scotia used to sing a ballad containing these lines:

"Sometimes on deck, sometimes aloft,
Sometimes I am below
But Mary she's still in my eye
True love commands me so!"

If this were more than a song, it is probable that the sailor-boy could not concentrate, though one may suspect that the captain had a different name for it. I would not venture to suggest the proper remedy for lack of concentration due to lovesickness. But in other cases, where motives springing from family or other stresses have tangled themselves up, the theory of Freud and Lewin does offer a solution.

Psychologists have long known that lack of concen-

tration can often be cured by straightening out the motives. The disconcerting thing is that theory provides no explanation of why this is so, conventional theory, that is. It is not much use to tell a boy: "The wrong associations come to your mind." He will immediately answer: "I know it, but tell me how to prevent it." He will not receive any particular comfort either if you tell him he has the wrong determining tendencies! But if you show him that his motives are badly scrambled, he can often make his own decision as to what he wants. This is sometimes a very difficult thing to do and in many cases it needs the guidance of an expert.

The practical rule is: *take care of the motives and the associations will take care of themselves!* And this is, after all, exactly what Lewin said! But we do badly need some more experiments on it all!

If then you ask a psychologist what directs your thinking in an orderly way towards the goal when you solve a problem, you put him in rather a quandary. He will be likely to tell you something like this, "The explanation must include association, although experimenters and other critics have made it difficult to see how ordinary association can work. It must also include motive. I do not know what is the relation between the two!"

In fact, most psychologists are more or less sitting on the fence about the important question of the guidance of thought, although some very able people have decided for one side or the other.

7. THE FLASH OF INSIGHT

EVERYBODY who reads detective stories knows the importance of the "clue." A crime is committed, and the police are called. The circumstances point to somebody as the culprit, or they point to suicide or to nobody at all. The detective, generally some kind of eccentric, arrives, pokes about, and with a cry of triumph discovers some trifle the others have overlooked. Later it appears that this overlooked object has transformed the whole situation for him. It has "thrown a flood of light on the mystery."

One of the clues I remember is the clock which had stopped at a certain time, indicating the hour of the murder. The detective starts the clock and turns the minute hand round to twelve, when the wrong hour strikes! The murderer had purposely stopped the clock and changed the hour hand, forgetting to change the striking mechanism also.

Then there was the apparent suicide of a woman on a gravel walk. The detective notices a silvery line across her skirt, which he sees to be the track of a slug. There are no slugs on gravel, so she must have been moved after death and probably had not committed suicide.

Again, a famous violinist has been found dead in his accompanist's room. A violin is lying on the table in its case. After fingerprints have been taken, the detective absent-

mindedly plays a few bars of Bach (on occasion the detective of fiction can play Bach, show an intimate acquaintance with the poetry of Charles the Second's time, and tell you the best hotel in Marseilles) and suddenly puts down the fiddle. It is tuned a quarter tone above the piano! The violin (or the grand piano!) has been changed! And so on. The reader can readily think of a dozen more.

In its modern form the detective story is about a hundred years old. But it is only during the last twenty-five years that the psychologist has given special attention to the process of thought involved in the "clue." Only he did not know he was doing anything so frivolous!

THE CLUE BRINGS INSIGHT

Through the clue, the problem is re-centered. Factors which previously had no meaning, or a wrong meaning, are now seen to depend on it and on each other. The whole situation is mentally re-arranged. *When this occurs to any of us we have a peculiar experience called a "flash of insight."* We often cry out in delight, "That's it!" The clue is the part of the situation on which "insight" often hinges. This aspect of thought has been particularly stressed by the "Gestalt" (or Configuration) group of psychologists.

Notice that the "flash of insight" is an aspect of thinking, not a special kind of thinking. Like trial and error it is found in most cases of thought, including many of the instances already given. Sometimes trial and error is obvious, and insight small; occasionally there is little or no trial and error while the "flash of insight" is very noticeable. These

are exceptions, however. Most cases of thinking combine the two.*

There will be more about all this in the rest of the chapter.

A clue is often contained in the original situation. As the thinker looks, suddenly the picture transforms itself. It is

THE TEEMING BRAIN

From Edward B. Titchener: Textbook of Psychology, *New York, The Macmillan Company, 1915. Used by permission.*

much like the puzzles on the children's pages of the newspapers, labeled "Find the policeman," or "Where is the submarine?" At the moment of finding the hidden object the figure seems suddenly to rearrange itself, and with a flash a new figure seems to emerge out of the page. The same lines are *seen differently*. Often the child, and for that matter the adult, too, will call out: "There it is!" This process of suddenly finding the hidden object, with the ac-

* Whether all thinking contains some measure of insight I would not want to decide here.

companying experience of "There it is!" is very close to the flash of insight in thinking.

"This summer," a young girl writes, "while we were sailing with some friends, our boat tipped in the middle of the river. The problem was to get to shore. I thought of yelling for help or having someone swim for shore, but it was too far. We got the boat upright and bailed it out with our bathing caps, but could not get the sail up. The problem was now to find a utensil for paddling. Suddenly I had the idea of removing the floor boards and using them for paddles. This came all at once. There was no gradual change."

Here, without any change in what is actually present, the whole situation is suddenly re-centered on the boards at the bottom of the boat. From plain boards, they become tools by which the sailors can get to shore. They have, in a sense, been transformed into oars or paddles, into a clue to the solution of the problem. As the Gestalt psychologists put it, the problem situation has been restructured in such a way that the boards, formerly an irrelevant detail, now play a central part in the activity of getting to shore. The transformation occurs quite suddenly.

A similar example was given several chapters earlier. The boy saw his baby brother drifting out into the lake and suddenly caught sight of the neighbor's boathouse, from which he took a boat and rowed out to his brother.

In more elaborate kinds of thinking the transformation is sometimes made through some object that does not belong to the original situation. This often happens in scientific thought. The most famous example is the well-known story of Archimedes, the great Greek mathematician. It has been told many times, but is worth repeating. It is the orig-

inal scientific detective story, with Archimedes running true to type as the eccentric genius who gets a clue and solves the problem.

"King Hiero had recently succeeded to the throne of Syracuse and decided to place a golden crown in a temple as a thank offering to the gods. So he made a contract at a fixed price, and weighed out the gold for the contractor at the royal scales. At the appointed time the contractor delivered his handiwork beautifully made, and the king was delighted. At the scales it was seen that the contractor had kept the original weight of the gold. Later a charge was made that gold had been removed and an equivalent weight of silver substituted.

"Hiero was furious at being fooled, and, not being able to find any way of detecting the theft, asked Archimedes to put his thought to the matter.

"While Archimedes was bearing the problem in his mind, he happened to get into a bath and noticed that when he got into the tub exactly the same amount of water flowed over the side as the volume of his body that was under water. Perceiving that this gave him a clue to the problem, he promptly leapt from the tub in a rush of joy and ran home naked, shouting loudly to all the world that he had found the solution. As he ran, he called again and again in Greek, 'Eureka, Eureka . . . I have found it, I have found it.' "

This is the story as the ancient writer * tells it. He goes on to say that Archimedes weighed out equal masses of

* Vitruvius, in his book on architecture, probably written about the beginning of the Christian era.

gold and silver, and placed each of them in water. Since it was lighter bulk for bulk, the silver displaced more water. Then he tested the crown and found that it displaced too much water for pure gold, so that the contractor must have cheated. By a simple experiment and a little arithmetic he was able to show how much silver had been substituted. Thus was born the theory of what scientists now call "specific gravity"; every high school boy in his first year physics now repeats the experiment of Archimedes.

Archimedes' problem was re-centered around the volume of water displaced. This re-centering process made possible a series of thoughts and actions leading directly to the goal, which was to find the amount of silver, if any, present in the crown. Before it happened, the scientist's thoughts led nowhere. The clue brought order into the tangle. Here the clue occurred in an entirely fresh context. Something had to be brought into the situation from outside before solution was possible. Nevertheless, the experience of finding the clue gave a great thrill to the excited man; and indeed a well-known modern scientist, Dr. Bancroft, has suggested that the general name "*Eureka*" should be given to the flash of scientific illumination which the story illustrates so well.

Notice that the clue came by chance, although of course it was not by chance that Archimedes recognized it. Later in this chapter it will be seen that this is often the case.

A modern scientific instance is given by Drs. W. Platt and R. A. Baker in their interesting article on the relation of the scientific hunch to research. A chemist, who does not give his name, writes as follows:

"In flying over smooth water I observed the image of the plane in the water. This could be seen at an altitude of

eight to ten thousand feet. A few days later, while resting and loafing on the beach, it dawned on me that this image would photograph in motion pictures from the plane, and establish the vertical position in ballistic studies [that is, studies of projectiles, such as bombs, in motion]. This idea was most useful in determining facts previously unknown." * Here the clue which brings order into a scientific problem comes again from outside. In this example, nothing is said of the mental processes of the thinker.

Often the clue, with its attendant insight, does not come from actual observation, chance or otherwise, but from straight memory. Thus Drs. Platt and Baker report the description of Dr. G. A. Abbott who had been working on a difficult problem in physical chemistry: ". . . After intense concentration and many vain attempts to overcome this difficulty I reluctantly decided to abandon the method. I was tired and discouraged and hungry. . . . Freeing my mind of all thought of the problem I walked briskly down Tremont Street, when suddenly, at a definite spot which I could locate today—as if from the clear sky above me—an idea popped into my head as suddenly and emphatically as if a voice had shouted it in these words." * Then follows a statement of Dr. Abbott's successful idea, which is rather technical, depending on a special use of the centrifuge, a laboratory form of the cream separator, which as it rotates throws the heavier parts of a liquid outwards.

Although everybody has experienced it, the flash of insight is difficult to describe. Often the word "light" or "illumination" is used, and Graham Wallas, in his book, *The Art of Thought*, includes "illumination" as one of his

* *Journal of Chemical Education*, 1931, 8, pp. 1978, 1977.

four stages of thought. The famous mathematician Gauss "succeeded, not by laborious efforts but by the grace of God. Like a sudden flash of lightning the riddle happened to be solved." Poincaré, another great mathematician, speaks of the appearance of sudden illumination. The philosopher Hobbes used to take out his notebook "as soon as a thought darted." Very often people describing their own trains of thought write: "In a flash the solution came to me." Like Gauss, others speak of a streak of lightning.

Almost exactly the same language is used by subjects in the psychological laboratory. Even before the Gestalt psychologists had drawn attention to the flash of insight, people given mechanical puzzles to solve remarked on the unique experience of the flash. "It came as an extremely sudden transformation, a 'flash' experience." * Apparently the flash sometimes occurs when there is no special clue. At least, many of the writers and many subjects in the laboratory do not report one. A genuine clue is followed by insight; but insight can apparently occur without one. Inventors sometimes say that the solution that came in a flash was "something like" something they were observing at the time.

A CLUE MAY BE PRESENT WITHOUT BEING RECOGNIZED

An unrecognized clue has been shown to occur sometimes in the laboratory. For example, in a well-known ex-

* H. Ruger, *The Psychology of Efficiency*. New York: Columbia University Press, 1926, p. 33. This was originally written in 1910, before the Gestalt psychology was developed.

periment a person was required to tie together two ropes which hung from the ceiling, but which seemed too short to reach each other. After trying without success to bring one rope to the other, the subject was often at a standstill. The experimenter then introduced a "clue" by slightly swinging one of the ropes. This enabled the problem to be solved by swinging one rope and walking towards it with the other. But some people were not conscious of the clue at all, and some indeed insisted afterwards that it had not been given! This pretty experiment well illustrates the general nature of what happens when sudden insight occurs. The ropes are first seen as two stationary objects. When the clue is given, one of them is "transformed" into an object that can swing towards the other, and action follows which leads to a solution. The Gestalt psychologists make much of this transformation, which has been observed in many experiments.

Of course we should not be justified in concluding, from this and other experiments, that because a clue is sometimes present and not recognized, there must always be a clue somewhere in the problem situation. Sometimes we have seen that a clue must be supplied by the thinker—like the catalyst which starts a chemical reaction, or the grain of sand that starts crystallization in a concentrated solution.

PRODUCTIVE THINKING

According to the Gestalt psychologists, it is this transformation which makes thinking productive, rather than merely reproductive. When a girl buys a stick of gum,

opens the packet, and chews the gum, she is allowing habit to take hold of her actions, and most of our everyday activities are done in this way. This is indeed the value of habit. It does take over our everyday activities and leave our attention free for more important matters when they arise. But remember the girl in Chapter Two. She takes a piece of gum, chews it, and puts it on the end of a stick to get a dime from beneath the grating. She has no habit to get the dime for her. She does indeed *use* the old habit of chewing gum; but she uses it to build up something over and above the habit, something new. This is because gum has been transformed from a thing-to-chew to something-I-can-get-the-coin-with. She has insight when she makes the transformation.

A boy tells of watching his sister skate too near an open place in the ice. He called after her, and she suddenly stopped, causing the ice to break. She fell into the water but managed to catch hold of the edge of the ice.

"I yelled for the others, and began to creep out on my stomach. The ice cracked ominously, and I could go no further. The rest of the party were standing round helpless, watching my sister gradually lose her hold. Then I suddenly remembered our bench and shouted for the boys to bring it. Just then my sister lost her hold, and I had to go in. I held her head above water with one hand and onto the ice with the other. Meanwhile the boys brought up the bench, turned it upside down and pushed it to me. The lightest fellow walked along it and helped my sister out and then me."

See how reasoning continually adapts to changing circumstances, and at the same time transforms them! The

bench becomes no longer "something to sit on," as the little child says, but a "plank" which will support the rescuers. Before the transformation can be made actual, the bench has to be turned up and then pushed over the ice. The Gestalt people point out that this kind of thought is productive. Something new has come into being; a mental creation has emerged.

This "newness" is one of the striking things about the flash of insight. Research workers have said, "I wondered why I had never thought of it before," "The right way dawned upon me without effort, seemingly from heaven." (Platt and Baker). Professor Kelley, the eminent statistician, who watched children in the classroom, speaks somewhere of the dewy-fresh solutions by which children solve problems in the classroom, if we let them. A previous chapter showed how Luchins, a pupil of Wertheimer, the dean of Gestalt psychologists, found that much classroom teaching spoiled children's thinking by forcing them to do what they have been told, rather than what the problem called for. There is no doubt that much of our classroom teaching does tend to produce children who work by textbook and by rule, reproductively rather than constructively.

MORE ON THE USE AND ABUSE OF RULES AND HABITS

Once again, rules and habits are a good thing. They must be learned, and children must be taught to apply them. But we have already seen that they must be kept in their place,

which is to provide automatic responses to routine situations; if they are allowed to do more than this, they may make fools of us. On the other hand, a novel piece of reasoning has great charm; that is part of our delight in a successful detective story. If we give the child a chance he will find great pleasure in making new solutions of his own. To make a new solution gives the same pleasure as to make a new picture, a new poem, or a new costume. It is the pleasure of creation. That is why some have spoken of the Art of Thinking. If the world is to pull itself out of the muddle into which it has got itself, we must breed a generation which will look at things not through the blinders of marks, rules, and texts, but directly and without blinking.

People often talk as though education may be a positive hindrance as far as artistic creation is concerned. One of our great stylists, John Bunyan, had hardly any schooling. Our greatest writer, Shakespeare, had "little Latin and less Greek." Those who are concerned with our national literature complain of the machine-made short story. Pictorial artists complain that people paint not what they see but what they think they ought to see, what they have seen in other pictures.

Yet, once again, there *are* rules which one must learn, both in literature and in other forms of production. The great artistic innovators have almost always been great students also of what has been done in the past. Wagner spent many years studying the methods of the classical musicians. Turner's early work was founded on the work of old masters, with their strong darks; only later did he reduce them, adding his own pale general tones. Goethe was a tremendous student of literature, both ancient and

modern. Bunyan took his training in literary method from the Bible; Shakespeare learned to write plays by acting those which other people had written—as well as by watching the box office! Milton, whose best work was as fresh as dew on a lawn, had an enormous knowledge of the Greek and Latin poets, as well as of those of other literatures. Beethoven, one of the greatest innovators of them all, was prodigiously learned, and so was Bach. And so on. These great men were able to break the rules because they knew them.

Today, a child must be taught the necessary habits of writing, of calculating; he must also be taught to create, that is, not to let habit be his master.

At the entrance to New York harbor the Goddess of Liberty should be shown crossing her sword with the Goddess of Habit. The two are eternally opposed; both are needed if our society is to survive. It is the classroom teacher's business to keep the peace between them. She must preserve the balance between the old and the new. It is an important and delicate job, one which would tax the very best and the most patient of mankind.

INSIGHT MAY BE INCOMPLETE AT FIRST

Although it occurs suddenly, insight need not always be complete at first. For example, much of what we ordinarily call logical reasoning shows a succession of small insights. They go, as we say, *step by step*, each step gradually improving the thinker's insight until the final step, which

illuminates the whole situation completely. Each step occurs by the sudden inclusion of new facts, and makes the way ready for the next, until complete insight comes. The process may be seen in many detective stories, where clue follows clue until everything is understood. It is seen also in many scientific investigations.

In a logical train of reasoning the thinker may require a series of insight—steps which are none the less sudden because they are small. It is a great mistake to assume that the work is done when the first insight has occurred.

You will remember the story that Newton began to think about gravitation when he saw an apple fall. The account says its flashed on him that just as the earth attracted the apple, so every particle in the universe attracted each other particle, the moon falling towards the earth, the earth and other planets towards the sun. Here was insight on a majestic scale. The moon and planets and the countless falling objects of the earth are brought together in one stupendous feat of integration. The windfall is transformed into the Golden Apple, the clue to universal gravity. If, as the historians now seem to think, the story is true, that was the most stupendous windfall in history, because it was seen not as a windfall but as an instance of a cosmic law. There was novelty, suddenness, bringing together of previously unrelated facts; the world is re-centered on the motion of a worm-eaten fruit.

And yet the problem was only just begun. Hundreds of hours of concentrated thought had to follow that first flash. Newton admitted that he discovered the law of gravitation by always thinking about it. The insight had to be completed, although we do not know the steps by which this

was accomplished. Many young men think it is enough to have a bright idea and let it go at that. We may all take humble example by the great scientist who was not content with an interesting speculation. A lesser man might have rushed to read a paper before the Cambridge dons, who would probably have proved him wrong by argument and by appeal to Aristotle. Had this happened, the science of navigation, not to speak of science in general, might have been set back for a hundred years.

Laboratory experiments, also, seem to show that complete insight may on occasion take time. The learning curves of rats in the maze often drop suddenly after the animals have suddenly "got the idea." After this, ten or twenty trials may be necessary, depending on the difficulty of the maze, before the animal gradually reaches his best performance. Some of this later improvement probably comes because the animal has to learn the correct movements, like a pianist or a typist. But many experimenters think that some of it at least is due to the gradual improvement of insight. In many cases human beings also, learning what is called a stylus maze, which must be threaded by a metal pointer, show a sudden improvement after the first trial or so. This is followed by gradual improvement for four or five trials more. Fifteen or twenty further practices may then be necessary before they reach their best performance. One experimenter found that the sudden drop was greatly lessened by showing the maze beforehand. This perhaps gave his subjects "the idea." These experiments seem to illustrate the fact that *though insight comes suddenly it may at first be only partial*, and is often improved

by further practice. It is only fair to say, however, that some psychologists interpret these experiments in other ways.

MURDERER AT LARGE

Both insight and trial and error seem to be necessary for our thought. Each seems to help the other. A doctor, father of one of my students, was awakened early one morning by a bright beam of light coming into the room. Startled from his sleep, says the account, he could not understand what was happening. Then he saw that the light came from a flashlight, and wondered whether a burglar was in the house. He sat up in bed and found that the light came from outside. So it was not a burglar trying to blind him. Hearing voices in the garden, he ran to the window. Half a dozen figures were walking about with flashlights pointed at the ground. One of them said: "I can't find a trace here, but we had better search the house." He recognized policemen, searching for footmarks or other traces. He decided that a serious crime must have been committed to bring out all these men.

The next day a murderer was captured a few miles away. He had killed a police officer.

This shows insight gradually developing, step by step, in a practical situation, as the result of action and some trial and error. First the light is connected with its source, a flashlight. Mental trial follows: "Is it a burglar?" Action is followed by the successive insights, "people searching," "police searching for footmarks," "police searching for a

major criminal." In this practical situation one clue follows another, just as in a detective story, the thinking being re-centered on each in turn. Each is transformed as it becomes part of a larger setting. The light becomes a flashlight, this becomes part of a search, and so on.

INSIGHT IS GENERALLY FOLLOWED BY WORK

Thus the first insight may be only the beginning. Work must be done to test it, and unless this is done, we may be left with a perfectly good idea hanging in the air. John H. Barr is quoted as speaking of the heart-breaking grind which must follow conception in all but the simplest problems of invention. Other successful inventors speak of working out their thoughts to completion, bringing the idea into a clear and concise form, and so on. One inventor states that a man's ability to invent depends on the ability to guess, plus the thoroughness with which the guesses are analyzed scientifically.* *Work is necessary* both to improve good insights and to expose bad ones for what they are. This is all done through trial and error. Those who tend to rely too much on the bright idea should remember the old saw that art is one tenth inspiration and nine tenths perspiration.

The ancients used to say that Minerva, goddess of wisdom and invention, sprang into life fully armored from the brain of Jupiter. They seem to have underestimated the

* Joseph Rossman, *The Psychology of the Inventor*. Inventors' Publishing Co., 1931.

necessity for patient work after the original idea has come. The Greeks, who invented this fable, would probably expect to have the bright idea themselves, and to hand over to some slave the work of putting it into action. Some historians have thought that the Greeks were held back from great advances in physical science because their thinkers were not willing to work with their own hands. There is no royal road to thinking. You have to do your own, and part of the job is the testing and working out of your own bright ideas.

WHEN DOES INSIGHT COME?

If you come to think about it, the question, "When does insight come?" is one which cannot easily be brought into the laboratory. Thinking is a delicate matter at all times, easily disturbed by the laboratory atmosphere. We cannot transfer the everyday man bodily into the laboratory to live out his everyday life. So that a special difficulty arises when we ask the question, "When does insight occur in ordinary life?" However, there is some evidence. It tends to show that in an experimental situation insight often comes after a period of delay. Sultan, Professor Köhler's "genius" chimpanzee, first jumped up and down in front of the goal he could not reach, like his more stupid brothers. Being a genius, he soon stopped this useless activity, paced about for a while, then suddenly stood still in front of the box and quickly moved it so that he could jump from it to get the banana. A girl of thirty-two months was shown a

toy aeroplane hung from the ceiling, too high for her to reach. At first she excitedly tried with one hand then the other, then with both. On complaining to the experimenter, she was told to try again. After two minutes she saw a hollow block (placed there on purpose), pounced on it and sobbed, "I think this will help." She placed the block clumsily but managed to swing the aeroplane. She was, says the experimenter, "Radiant with joy."

You can often see the same delay outside the laboratory when adults are solving difficult problems. It is sometimes stretched over hours, months, or even years. Once again, if you are not tired of him, remember that for four years Gauss vainly tried to prove a theorem. "At last, two days ago, I succeeded, not by dint of painful effort but, so to speak, by the grace of God. As a sudden flash of light the puzzle was solved . . . I am not in a position to point to the thread which joins what I knew previously and what I have succeeded in doing." The mathematician, Poincaré, had been trying for some weeks to solve a problem, and had already obtained some light on it. In disgust that he could not complete the solution, he went for a few days' holiday to the seaside. One day, as he was walking on the cliffs, further insight came quickly, suddenly and certainly. This was followed by a period of intense mental work. Poincaré says that his illuminations were the product of "long unconscious labor."

Thus insight is often delayed. A fore-period often elapses, during which a person works on the problem. If Poincaré is right (and many others agree with him), much of this work may go on without the person's realizing it.

So we often have to work both before insight comes in order to obtain it, and afterwards in order to improve it.

Good ideas have to be worked for, and worked after!

As to the occasions when insight occurs in everyday life, thinkers have recorded a bewildering number of them. Poincaré lay in bed, or he walked on the cliff, or crossed a street. A number of inventors report that ideas often come when they are half asleep. Dressing, shaving, sitting in church or at a concert, all are mentioned. One professional inventor follows Archimedes. He says that the basic idea always comes when he is in his bath. His head is clearer then, and he is free from interruption. Reading a newspaper in bed, lying in bed with gout, listening to a sermon, have all been mentioned as occasions for inventors' ideas. The great scientist Helmholtz liked to walk up wooded hills on a sunny day. Darwin had an important flash of vision while he was riding in a carriage.

These are, of course, not laboratory results, but there is no special reason to doubt them. If they and other statements are put together, two or three things come out. The flash may come when the thinker is in surroundings that apparently had nothing to do with his problem. It may come during or after a period of mental or physical relaxation. It may come when a person is engaged on other work.

We used to be told that "All work and no play makes Jack a dull boy."

Certainly what evidence we have seems to favor a degree of relaxation for creative work. Did not Newton himself sit in the orchard? And as Milton has said:

> "Wisdom's self
> Oft seeks to sweet retired solitude."

WHEN CHANCE BRINGS THE CLUE

And finally, what of the accidental clue which leads to insight? Doesn't chance often solve a problem for us?

Experiment has shown that accident may indeed provide the missing clue. Once more, start with the chimpanzee. Köhler's Sultan had been given the problem of getting a banana by two bamboos, which fitted into each other like the lengths of a fishing rod. Alone, neither stick was long enough. Köhler knew that Sultan was a clever animal; but he was not clever enough to think this one out. The animal worked for an hour, using various methods in vain. Among other things he did was to lay the two sticks end to end, making indeed a contact with the goal, but a useless one. Köhler grew tired of watching and went away. Then the keeper saw the animal sit on a box, pull in the bamboos and play aimlessly with them. By accident, Sultan held the sticks end to end and in line. Then he fitted them together, sprang to the bars and began to draw in a banana. The sticks fell apart. Sultan fitted them together again. The next day he fitted three bamboos into each other.

The same kind of thing has often happened with human subjects working on mechanical puzzles. People often first do these puzzles, then observe how they did them, gradually or suddenly acquiring insight into the method. One young man in my laboratory said: "I fiddled round, twisted the ring, and found that it worked." These accidental solutions are in fact so numerous, that the trial and error hypothesis was built on them.

Many human inventions have happened in the same way. So many that the Frenchman Souriau believed that chance is the most important factor in invention. Thus Galileo is said to have invented the pendulum after watching a chandelier accidentally swing in church. The story says that he counted the time by his pulse, and observed that this was the same whatever the distance of the swing. It was a short step to the idea of using the pendulum to regulate a clock. To come to more modern times, Goodyear accidentally dropped a mixture of sulphur and rubber on a hot stove. Instead of melting, it "charred like leather." Vulcanized rubber, which can be used without melting in summer, had been born. Daguerre left an exposed photographic plate in a dish overnight. The next morning he was astonished to find that the picture had appeared, and was able to trace this effect to mercury vapor from an open dish. This was the first "developed" photograph. Becquerel noticed that a wrapped photographic plate was clouded by compounds of uranium, and that other substances had the same effect. This was the first observation of radioactivity. The most active substance was later isolated by the Curies, and called radium.

One of the most striking cases was related by Sir Alexander Fleming. "In 1928 I was playing about with some staphylococci on a culture plate. As soon as you open a culture plate you are asking for trouble. One of these bits of trouble happened to be penicillin, which was very fortunate. . . . I noticed the staphylococci were dissolving near the mold . . . I had never seen that before. . . . So I went into penicillin research." *

* Toronto *Globe and Mail*, Staff report dated June 7, 1945.

Many more cases could be given. Many will be found in J. Rossman's *Psychology of the Inventor*. Mr. Rossman tells us that seventy-five out of two hundred and fifty-nine inventors stated that chance had played a part in their inventions.

But if you are tempted to expect chance to solve your problems, you will, once again, find yourself becoming a psychological Micawber, always waiting hopefully for something to turn up. Chance favors the man who is prepared for it and can use it. Without the proper preparation, even Newton might have lain around all his life in his father's orchard, and Becquerel might have clouded photographic plates for a lifetime. Galileo had already done extensive research on falling bodies. Goodyear had been trying for years to find what chance finally threw onto his stove. The chance event must happen to the man with the acute brain and the right preparation. Nobody else will be able to use it. This is really the point of the detective stories. The dirt which chance has thrown on So-and-so's shoes is there for all to see. It is a clue only for Sherlock Holmes. For poor Doctor Watson, the man who cannot make head or tail of the simplest of slit throats, it is just dirt on a shoe.

To quote the ancients once more, they rightly called their goddess *Chance-with-the-Key*. But the key is of no use unless the man is there who knows which lock it fits.

INSIGHT MAY BE DECEPTIVE

Finally, a word of warning. Clear, illuminating, and apparently final though your idea may be, it need not neces-

sarily be true. Remember the White Knight in *Through the Looking-Glass*, who was always having good ideas that were no good! And learn from a scientific friend of mine, who lay in bed one night trying to piece together certain puzzling results of experiment. Suddenly, like a flash, he had it. The whole thing lay clear before his eyes. He could hardly wait till he got to his laboratory the next morning to try out a test of his insight. Sure enough, the first test was exactly what he had hoped for, and so was the second one. But every experiment he made after that went the opposite way. For months he worked on the problem, and finally disproved his original idea! As he said to me, the only thing that was wrong with that flash of insight was that it wasn't correct!

Putting together what has been said in this chapter, with certain laboratory results which have not been mentioned, you can say:

(1) Intense mental concentration favours the flash of insight.

(2) It comes only to those who have the right kind of preparation, through experience or study. This means you have to work for it. The clue may be under your nose, waiting for a genius to see it.

(3) It can generally be put to practical use only by those who take the trouble to make it clearer and more precise. That means you have to work after it. Better men than you have worked for years before their idea came, and for years after it came.

(4) Try to avoid fixed assumptions. The way to bad thinking is paved with them. Master your subject; do not let it master you.

(5) Do not try to hurry the idea. It may come when you least expect it.

(6) Do not flog your mind. Change of scene, relaxation, often help.

(7) Don't expect chance to drop in one day and do the work. Lady Luck has to be wooed like any other. She likes to find the chores done when she arrives.

(8) Don't assume that because your insight is clear and illuminating, it is necessarily correct.

8. IMAGINATION IN THINKING

I WAS recently discussing with a lady of my family where a book was to be found on a bookshelf in another room. She thought one place, I another.

"Well, I'll go and see if you are right," I said.

"You don't need to go for that," the lady answered. "I can see it just as plainly as though I was there. It's a brown book, and it's on the bottom shelf right at the end on the left."

I did go, and found the book. The lady was right.

The lady had a "mental picture" of the shelf with the book in its place. These mental pictures, which come "in the mind's eye," are called "images" by the psychologist. The process of forming them he calls "imagination," though sometimes he also uses this word, as the man in the street uses it, to mean the production of new ideas as in literature, art, and so on. In this chapter the word imagination will be used in the narrower sense. Imagination will then mean the formation of images out of one's own past experience.

YOU HAVE MANY KINDS OF MENTAL IMAGES

There are other kinds of images besides the mental picture. Some people can hear things that have happened in the past. I am personally interested in this, since I myself apparently had an unusual measure of this ability as a boy and young man. Even now, I can hear "in my mind's ear" a familiar sonata, with the harmonizing notes. I can stress one of the parts and, with an effort, hear the music with one part omitted. This ability is, of course, common with musicians. The great composers had it to a remarkable degree. In a passage already quoted, Mozart describes how he heard music when he was alone, in a carriage, after a meal, or in bed, and selected what he wanted. Sometimes, but not always, he would hum the theme aloud. This, of course, is "constructive imagination" but it worked by means of images. One of the great composers has said that the ability to hear new melodies as one goes about one's everyday affairs is a test of creative talent.

But we need not go to Mozart and Beethoven. Many people have the ability to form quite strong auditory images. If a group of thirty people is asked for example to "imagine" opening an umbrella, two or three will generally report that the sound (the "plop" one young woman called it) is the most noticeable part of the imagined experience.

In addition to auditory and visual imagery there is imagery of movement—kinaesthetic imagery, it is called technically. When asked to think of opening an umbrella,

quite a number of people will "feel" the tension in their right arm; people asked to imagine pumping up a bicycle tire can often feel slight regular movements in their arm. These invisible contractions have been electrically recorded, so that what is called kinaesthetic imagery may often be kinaesthetic sensation, that is, actual sensation from the muscles.

Such "movement" images, or slight sensations, are very common in our everyday life, and can generally be detected during thinking if one knows how to look for them. Sometimes the small movements causing them are exaggerated so that they can easily be seen by other people. Thus children like to ask each other what an accordion or a spiral staircase is. Generally you may see the arms of the other person going in and out, or up and round. I watched a man the other day as he described how he did a job of carpentering work. His hands were continually moving, in keeping with the sawing and measuring he was describing. All these are exaggerations of the kind of slight movements which are apparently taking place in most of us most of the time.

But the tale of the images is not yet told. There are images of touch. Think how velvet feels. While reading this, you probably felt something in your first finger. If so, it was an image of touch. Try thinking how sand feels. You probably had a different image. There are also images of taste and of smell. There are what are known as organic images, such as that of nausea or of stomach-ache. You can probably imagine what it feels like to be nauseated.

IMAGES AND YOUR MENTAL LIFE

Our mental life is shot through and through with such images, although we generally do not notice them. How often have you thought of the pressure on the soles of your feet today? It is after twelve in the morning, and this is the first time this pressure has come to my mind. And yet my feet have been pressing on the ground for over four hours, and the nerves have been delivering their impulses all the time. If you have tight shoes or sore feet you will notice it. In that case you will say that the discomfort has "drawn your attention" to the pressure. And this is what the psychologist says, too, although the phrase is beginning to go out of fashion.

In the same way, when there are special reasons you notice your imagery. Many people have half-waking pictures, as they go to sleep or wake in the morning. One man, for instance, saw a marble every night rolling up an inclined plane. When it reached the top he knew he would be asleep! This is known as a hypnagogic vision. It was a series of images which was noticed because it was repeated, because it was intense, and had little competition. People generally notice their dreams, though not always. People who say they never have dreams will generally find them, if you can make them watch carefully enough. And in general, when people tell you they have no images, you can almost always show them by the proper procedures in the psychological laboratory that they have a good many images to which, however, they ordinarily pay no attention.

Our everyday mental life is crowded with images of every kind. They come and go continually, at all times, when we are talking, eating, reading and thinking out a problem. Many of them we do not notice just as we do not notice other everyday things that are happening in our body. Sometimes, particularly during thinking, they are mere fragments, bits and scraps; sometimes fully formed pictures of something we are thinking of. We are so much in the habit of neglecting them that it is often difficult to see they are there. But when the psychologist calls special attention to them, they are found to be present most of the time. They seem to play an important part in much of our thinking.

IMAGE OR REALITY?

Images are much more intense in some people than in others. Some, like the lady to whom I referred at the beginning of the chapter, form very strong images, they claim as strong and clear as the original perception. In a famous investigation, Sir Francis Galton asked a hundred members of the Royal Society to imagine their breakfast table. Those with the ability highly developed stated that the imagined picture was "quite as bright as in the original scene," "perfectly clear and bright." Those who had it least, reported, "I seem to be almost destitute of visualizing power," "my powers are zero," and so on. Colors might vary from perfectly distinct, bright, and natural to no color at all. One may be fairly certain that those few who re-

ported no images did really experience them, if only in a fragmentary form.

Some have imagery that is so strong that they are able to see details they apparently did not notice at first observation. Sir Francis Galton tells an astonishing instance.

"Mr. Flinders Petrie,* . . . informs me that he habitually works out sums by aid of an imaginary sliding rule, which he sets in the desired way and reads off mentally. He does not usually visualize the whole rule but only that part of it with which he is at the moment concerned." This seems hardly credible to those of us who have relatively little and weak visual imagery. But I have heard of a similar instance from another reliable source.

Children often have strong imagery. They can often count from an image the number of buttons on a man's coat, or trace out the letters of a language they do not know, even in an alphabet they do not know, such as Greek. They can sometimes alter the image at will, and it remains as vivid as ever. This has been called *Eidetic Imagery*. It is found in few adults, but in many children. It seems to disappear in many children about the age of puberty.

It is probable that this is often the explanation of the performance of blindfold chess players. Some of them say that they can picture a chess board with different sets of men, red, white and black, ivory and wood, and can carry several such boards in their head at once. The chess master, Blackburne, could play sixteen or twenty blindfold games *at the same time!* This was apparently done through

* He later became an eminent Egyptologist. The quotation is from Galton's *Inquiries into Human Faculty*, p. 95.

imagery. It doesn't follow that power to play blindfold games brings greater ability in playing chess. Blackburne was beaten by Steinitz, who could play only six blindfold games!

Sir Francis Galton, who gives these details, speaks of people mentally reading from imaginary scores when playing the piano, or from imaginary manuscript when making speeches. "One statesman has assured me," he says, "that a certain hesitation in utterance which he has at times is due to his being plagued by the image of his manuscript speech with its original erasures and corrections." Another person told him that he wished he could get rid of his visual images, they were so brilliant and persistent.

Usually we can distinguish these images from reality, however strong they are. Under special conditions in the laboratory it is possible to produce images that people cannot distinguish from the real thing. If very faint lights have been thrown on a screen in a dark room, people are apt to see a light there when it is not there at all! They "imagine" they see it. The opposite may also happen. People may be led to think that a real picture on a screen is an image. In a famous experiment people were asked to visualize a banana on a screen in a dark room. An operator then threw a very faint picture of a banana on the screen, and gradually made it more intense until the person said he had a good image. What he saw was not an image but a real picture.

These cases are exceptions. They had to do with very faintly seen objects, pictured on a flat screen, and with faint images. Generally we have no difficulty in recognizing which is image and which is reality. When people regularly

have images they believe to be real objects, we speak of hallucinations, and this is often, though by no means always, a sign of mental illness. Thus, a friend of mine, who was going through a period of mental stress, was acting in a play. She tells me that all the time, in addition to the two other people actually on the stage, she "saw" two others which were not there at all! She has now completely recovered from her mental trouble. The hallucinations of the insane and of the alcoholic are of course incredibly real and lifelike, and they consist of exceptionally well-organized images.

It is tempting to say more of the fascinating subject of mental images, but this would take us too far from thinking. Enough has been said to make it clear that mental images exist of many kinds and of many degrees of intensity, and that the power of forming them varies greatly in different people.

WHAT PART DO THEY PLAY IN THOUGHT?

Though images are of undoubted help to some people in their thought, it does not follow that the strongest images are always the most useful, nor that those who have the most images are the best thinkers. Some, already mentioned, find their strong images a nuisance. For all their vivid imagery, children cannot reason as well as adults. Dr. Bowers, an able psychologist, now unfortunately lost to scientific research, found that the best adult reasoners were not necessarily those with the strongest imagery.

Galton found some eminent scientists who claimed they had no imagery, and certainly had very little; while others equally eminent had vivid imagery.

Apart from individual differences, the help that images give seems to vary with different kinds of thinking. The artist seems often to find it very useful, and many artists do seem to have intense images. This is true both of pictorial artists and of musicians. A painter friend of mine can imagine colored spots on a screen and move them about at will—a feat which I find completely impossible. I once asked my friend whether he could move such a green spot onto a bright red spot.

"Ugly, isn't it!" he answered!

When the artist uses images in his work he probably employs them much as one uses a diagram or blueprint. He sees what he wants "in his mind" instead of blocking it out on paper. Musical composers, also, work out the problems of composition in their heads by means of imagery. In the laboratory images have been found to be of use in judging tone-intervals.

It is easy to see why images are likely to be of special help in artistic thinking. The artist is working to produce particular things, particular paintings, particular pieces of music and so on. Images, as the philosophers have been telling us for a long time, are particular. An imaged triangle has a definite shape and color, an imaged tune, a definite quality, of a violin or piano, and so on. This use of images by the artist to save himself trouble is in line with the rest of our knowledge about thinking. You remember that in general the human being tends to work out problems "in

his head"; the less gifted animal has to make the actual movements.

In more abstract problem-thinking, also, an image may serve as a mental diagram. It is much better than an ordinary diagram drawn on the board or on paper because it can be changed or moved about at will, and sometimes seems even to improve itself without voluntary effort on the part of the thinker. Just as a diagram on the board is symbolic, so is a mental image often symbolic. If the image is of a moving object, a good visualizer can make it move.

A "lightning calculator" once astonished a group of psychologists by adding fifteen digits at a glance. When asked how he did it, he said that he formed a single image of all the digits at once, as though they were written in chalk on a freshly washed blackboard in his own handwriting. He was able to turn to one or other imaged item as he wished.

An inventor says that he studies his problem for several days, sometimes weeks. During this time he does not put a line on paper. In the end he is able to make a mental picture of a machine or tool, and can see it quite clearly *with the chief parts working*. His next step is to make a complete drawing. Finally he makes a model. Subjects in the laboratory, also, have said that they could make a drawing of their imagery. Here again, the inventor is making a particular thing, so that images may be of great use to him. Many, though not all, inventors report that they work in this way, first by forming images and then making a sketch. *The image is nature's preliminary sketch. It is flexible, it can be moved, added to and subtracted. It prepares the way for the final working diagram.*

Occasionally it may appear fully fledged, without any intermediate stages. Another inventor says:

"Waking up about two or three A.M. and lying in bed in perfect darkness I would suddenly have before me on the ceiling or on the wall every minute detail of a complicated wiring diagram of an automatic control system. Sometimes hundreds of wires would appear before me properly interconnected to accomplish just what I wanted to get in my conscious hours." *

Imagery in solving problems has been reported many times in the laboratory. An Irishman once said in my laboratory, "When you really watch your reasoning, images are what you have nothing else but of!" This may not be true of everybody, but it is certainly true of many. Dr. Ruger watched a number of subjects solving mechanical puzzles and recorded their observations on their thinking. He found that in his own thinking he analyzed the images in the same way as he analyzed the actual puzzles. In the case of certain puzzles and at certain stages it was a distinct advantage to put the puzzle where he could not see it, or to close his eyes and work it out. The image is here better than the perception, probably because the thinker could concentrate better on it and manipulate it more easily. In general, however, Dr. Ruger's subjects did not report much imagery, perhaps because they had the puzzle before them, which almost served as its own diagram.

People solving abstract problems in the laboratory do however mention a good deal of imagery, if they are asked

* M. M Goldenstein, quoted by J Rossman, in *The Psychology of the Inventor*. Inventors' Publishing Co, 1931, p. 107

and if they are good observers.

Here is a small problem for the reader.

Butter and lettuce are both foods. As belonging to the same class of things, namely food, they are called *co-ordinates*. A co-ordinate to blue would be yellow, since they are both colors. Now try this one. Watch carefully whether you have any mental pictures, and what type they are, if there are any, whether visual, auditory, kinaesthetic, and so on. You will be able to compare your thinking with that of a famous psychologist. Here is the question:

NAME A CO-ORDINATE TO CELLAR.

Well, what did you get? Did you have any images? Did you "speak to yourself"? That is another kind of imagery, not yet mentioned. Or how would you describe your conscious thinking?

This is what Dr. Dürr, the eminent German scholar, said when given this small problem.

"Saw a house (schematic) * with cellar and upper storeys. I wanted to name the upper part. The word did not come."

He probably had in mind the answer which came to me as I wrote this, namely, "attic." You can see how he used his image, so to speak, to try to read off the answer, only the actual answer did not come.

These verbal problems can be made very difficult. For example, try this one:

Give a super-ordinate—that is, a class including both of them—to "invisible" and "inextended."

* He means, "with details left out."

If you do this in less than half a minute you are a better man than I am.

It is often hard to get everyday instances, from real life thinking, of the fleeting and elusive image. Students regularly report working problems in geometry by visualizing the construction after they have gone to bed. This is, again, using images as a diagram. One young woman says:

"I was just setting out for a party in my car when I noticed how dusty it looked. I thought: 'I really can't go with the car as dirty as that. There's no time to take it to the garage, though.' Then I had a vision of an old rag I had put into the glovebox. I rubbed the car over quickly with the rag."

A young man describes lying in bed and thinking out a difficult mathematical problem.

"I saw the symbols all separate and without any connection. Suddenly they seemed to click together in a circle, and I had the solution."

This is especially interesting, because an almost identical account is given by Kekule, the discoverer of the "benzine ring" which has been the foundation of modern organic chemistry. Kekule dreamed that the symbols for carbon and hydrogen were all joined together in a long train. Suddenly one end of the train bent round and joined with the other to make a circle. The Benzine Ring had been invented—and from it you and I get our ice-cream flavors, our dyes, many of our plastics and other "synthetic" products of coal tar.

People who have been specially asked to notice the imagery in their thinking have reported many interesting cases to me. A married man says:

"My wife wished to make a table center like one she saw illustrated in a magazine. It was oval, and she asked if I could make an exact copy, only larger.

"I began to cast about for ideas on drawing to scale. I had definite images of scale drawings I had made of squares, hexagons, etc. Then I remembered that you can trace an ellipse by tying the two ends of a string, stretching them over two pegs and guiding the pencil in the slack of the string. *I had a vivid image of the pencil tracing out an ellipse in this way.*"

Here the image seems to serve as a moving diagram of what was to be done. One feels that this young man had used his mathematics to good purpose!

Here is an example that has nothing to do with mathematics. A girl was sitting at her work table at about 11.00 P.M. She heard a number of raps, which seemed to come from outside the window.

"I was frightened, and dared not look towards the window. I visualized the open window and the little back yard, which is enclosed by a high fence. I saw also the back gate, which was locked, as always. I visualized a man getting through somehow and climbing up to my window. I had kinaesthetic imagery of jumping up and rushing to the hall. My imagery of unlocking the door and grasping the knob was very clear, as the door is sometimes difficult to open. I listened but heard nothing. I visualized the man standing outside and peering at me, . . ."

It turned out that the rapping was not from outside after all, but from a creaking bed upstairs. As a problem, this was simple. The solution came when she heard the bed creak. The imagery was exceptionally vivid, perhaps owing

to the girl's emotional state. Once more it serves as a mental diagram by which she tries to solve her problem.

HOW IMAGES ARE USED

In a laboratory investigation of thinking, one investigator found that images were used in five ways. They might provide material for working a problem; they might "anchor" the problem, that is, fix its essential parts in some way, or hold the meaning of the problem; they might regulate the problem, by laying down the general method by means of verbal imagery; for example, one subject saw two glass vessels, and "said to himself" *you'll have to solve by interchanging water in them.* Images might also illustrate the answer after it has come. Finally, through images a person might escape from a difficult problem.

The first four uses are exactly the uses one makes of a diagram or blue-print. The last, namely, escaping from the problem by means of images, is making a diagram of something other than the point at issue. It is mental doodling.

Dr. Claire Comstock, who made this experiment, found no images that were off the point. *All the people she questioned, in or out of the laboratory, used images in their thinking. Many said they needed them.*

Some images, particularly those of words, are only fragments. A man watching for a signal to lift his hand may say that he sees in his mind a bit of the yellow card that he is expecting. During complicated thinking a man may mentally say fragments of words, such as *bat* . . . for (electric) battery, *bin* . . . for binomial theorem, and so

on. It seems that in abstract and in more practiced thinking these fragments occur more frequently, and this also makes the image difficult to observe. Perhaps this partly accounts for the fact that those who are accustomed to think in abstract terms report less imagery.

Is imagery the whole of conscious thought?

Some have claimed that it is. In fact, even now, "Imageless thought" is a fighting word in certain quarters.

The answer really seems very simple, as Professor Woodworth of Columbia points out.

Is a blue-print the whole of engineering? Of course not. The engineer *makes* the blue-print for his own purposes.

The thinker *makes* the images, for his own purposes. He *uses* them as he uses action, perception, language, and possibly emotion.

Without something that can use it, an image, or even a group of images, would be of no value for thought. Many children could make a mental image of the binomial theorem all written out, or of Maxwell's famous equations, on which much of modern physics depends. Doubtless some could do this better than Einstein. But that would not make them better mathematical thinkers than Einstein.

There must be thought that is not an image, to give the thinker the meaning of the image. Many psychologists in many laboratories over two continents have told us this. So have many philosophers.

It means imageless thought!

As I said, this is a fighting word. Those who wish to fight about it may do so!

Thinking is the full time job of a fully working organism. It needs every resource at the command of each of us.

Some are by nature or by training supplied with better tools than others. Some people could never learn to use certain tools. A clumsy person could not learn to use the engraver's *burin*, that fine tool with which he makes a line drawing. A stupid person could not learn to use a complicated slide rule.

Some people, perhaps most, could not learn to use mathematics, the mental tool which more gifted men have devised to solve the problems of nature. Nobody would try to use a burin to cut a loaf of bread, nor a slide rule to mend a typewriter. Nor would they use the higher mathematics to measure a bushel of potatoes. Unless perhaps they were like the professors in Swift's city of Lagado, who "had found a device of plowing the ground with hogs," by burying six hundred or more acorns eight inches deep into the field.

In thinking, also, different problems need different mental tools. Some have the tools, some have not. Some who have them cannot use them. Those who have them do not always use them. Some are fluent with words, but they are not all Shakespeares. Some who have great ability with numbers and are called lightning calculators are feebleminded. Some have vivid mental images. If they have the needful abilities, these people may use their imagery to help them become great pictorial artists or musical composers. If they have no artistic ability or interest, but the kind of ability that makes a great philosopher, they will probably find that their images gradually become fainter and less frequent by lack of use. But different people do their thinking in so many different ways that only general statements can be made. There will always be exceptions.

Images are mental tools. They are useful for certain kinds of thinking such as that which the artist does. Even so, many artists apparently reach a high rank without making special use of them. *They are of less use for abstract thinking*, such as that of the philosopher. *Some people make great use of them, others apparently less.*

How can imagery be used in practical life? Certain memory systems do use it. A list of standard images is learned, such as that of a locomotive, a tent, and so on. These are used as a framework to remember disconnected items. The locomotive might be pictured as running over a toothbrush, the tent with a flag on it made of fly-screening, and so on. The method is described in a previous book.* I have seen a young man use this method to astonish a roomful of people by remembering twenty objects chosen at random by the members of a party. There is no doubt that imagery can be developed by training, and people I have known have claimed to derive great benefit from this kind of memory system.

In general, however, science is not yet in the position to give much advice about the uses of images, why they are used by some and not by others, and when they may profitably be used. About all that should be said at present is that some use them profitably, others may even find them a hindrance. Whatsoever scientific advice is more than this probably cometh of evil.

Of rules, then, not many can be given. It is safe to say:

(1) Mental images of all kinds, visual, auditory, movement, word, are abundant in reasoning. Visual and word

* Humphrey, *The Story of Man's Mind*. New York: Dodd, Mead and Company, 1932.

images are probably the most common.

(2) Many artists have very vivid images, and apparently use them in their work.

(3) Many inventors find visual images of great help.

(4) The more abstract the thought, apparently the less detailed the images.

(5) When images are used, they serve as a natural, often moving, blue-print, fixing plans and details. The blue-print is often symbolic, being something like the matches an old soldier uses to show the battle on the table.

(6) People apparently vary a great deal in the use they make of images in their thinking on the same kind of problems. (Conceivably this apparent difference is due to the fact that some are more aware of their images than others.)

(7) Imagery can be improved by practice. But science does not know enough yet to give any rules that will enable you either to make better use of the imagery you have, or to improve your thinking by improving your imagery.

9. THOUGHT AND ACTION

IN the great struggle of life against circumstance, action is of supreme importance. To find its food, to join its mate, to escape its enemy; to win money, attain ambition, gain social approval, a living creature must *do* something. A Greek philosopher said that man is the most intelligent of all living things because he has hands. Hands are the best working mechanism that nature has yet devised.

As we come up from the simplest living things to the most complex, better and better means have developed to economize on action. Action is expensive of time and energy, and nature is economically minded. The competition of life is hard. Any creature that wastes action or uses it inefficiently is at a disadvantage with its competitors.

Directed thought is the great economizer. You will remember that intelligent man tries out his actions in his head, while the more stupid animal often rushes about, wasting energy and time, and often losing its life in the process. You will remember also that even though human thought often seems to stretch out endlessly without issuing in action, yet some action may generally be found at the end of it all. The chess player working out a problem in bed seems to be thinking in a vacuum. Yet he generally does something about it, even if only to write the solution

on a post card to send to the chess-editor. The scientist may spend hours or months on a mathematical problem without observable action. When the solution comes he may type a few pages. He will generally *write* something or *do* something in the laboratory. Although action is often found without much directed thought, thought seems to be married to action.

THE MUSCLES ALWAYS ACT DURING THOUGHT

The marriage is even closer than one would think. For here research tells us a startling thing. *Even in those periods of apparent rest, when we seem to be thinking only and doing nothing, the muscles are still working. Action is still with us. During thought we cannot escape from it.*

Some years ago I was in an English laboratory with a young friend. He fastened an electrode to the upper part of my arm, and arranged wires so that they ran through a set of amplifying tubes to what is known as an oscilloscope. Now an oscilloscope has a small circular screen (in this case about four inches across) on which a line of light shows. When no current is passing, the line is straight. When there is a current, even a very small one, the line is disturbed, according to the kind and amount of current flowing. Since the amplifying tubes were powerful, the apparatus served as a sensitive detector of electrical changes. It worked in fact like a miscroscope for electric disturbances.

When my young friend, Dr. Rawdon Smith (he later

attained distinction by devising apparatus for aviators), threw in the first switch, the line shot dead across the screen, straight as a modern highway across a level plain. There was nothing to disturb it. Then he threw in a second switch connected with my arm. At once little spurts shot up, jags of disturbance, changing from instant to instant, now higher, now lower. The line now looked like the surface of a choppy sea. The spurts came from small currents made by the muscles in my arm.

These currents were caused by contractions of muscle fibers so small that to our eyes they were entirely invisible. What we saw was a bare arm to all appearance entirely relaxed and resting on a table. What the apparatus registered was muscle fibers slightly thickening, first one, then another, helter-skelter, and producing electric disturbances as they did so.

How could we tell that the muscles were the cause?

The apparatus could not be responsible. For the line was straight until the arm was brought into the circuit. In order to make sure, the experimenter said:

"Relax your arm. . . . Let it go. . . . Relax it. . . . Relax it more. . . . Let it go completely."

Gradually, as I let the arm go, the line straightened out, the jagged bursts sinking to little spurts, and these little by little to an occasional ripple. Finally it was nearly straight again for short periods at a time. At this stage the slightest interruption would send up a cascade. When the experimenter asked me the time, when someone put his head in at the door, when I thought I would be missing my bus, bursts of varying heights occurred. The whole process of quieting the arm took perhaps twenty minutes. Even then

I could not hold things quiet for more than a few moments.

This was only a small part of my body. Similar results could have been obtained from any other group of muscles —the leg, the thigh or even the eyelid!

But the really dramatic part was to come. The experimenter said:

"When I say go, imagine you are knocking out the heavyweight champion. You are really letting yourself go. Let him have it on the chin. . . . Ready . . . GO!"

The result was astonishing. The line seemed to explode instantaneously, filling the screen with smashes of light and darting needlepoints. The whole four-inch circle seemed to be lit up for a fraction of a second, and the line completely blotted out.

I am not a heavy man. Any blow of mine would doubtless feel like a playful punch to a heavyweight champion; so that I was gratified at the tempestuous effect of my effort—even if it was, as my young friend irreverently remarked, "a storm in an electrical teapot." Through it all, an onlooker would have seen two people quite motionless, in a roomful of apparatus, one with his arm resting quietly on a table. There was not a visible quiver from the muscles that had caused the four-inch cataclysm.

This informal and completely impromptu experiment showed that when I was merely *thinking* of doing something, my muscles were still acting, though on a small scale. Such invisible activity goes on during all thinking. *Thought never wholly frees itself from action.*

PROGRESSIVE RELAXATION

Edmund Jacobson, of the University of Chicago, has made an able study of this implicit muscular activity, as it is called. By an instrument which he calls the neurovoltmeter he has made many registrations of the electrical changes in the muscles during "mental" action. Let us see his method and some of his results.

Jacobson put his subjects through an elaborate training to relax. An important part of this training is to teach the subject to recognize the presence of muscular contraction however slight it may be. Starting from the large groups of muscles he goes gradually to smaller and smaller groups. Progress is slow but thorough. An hour may be spent on learning to relax the biceps muscles. A person who has learned to do this properly goes on to other muscles on succeeding days, those that flex the hand, move the thighs and the lungs, those across the chest, between the shoulders; those that wrinkle the brow, move the eyelids. Then come the muscles which move the eyes, which he must relax with eyes open as well as closed. The muscles by which we speak and swallow are also trained.

A person has to learn all this, just as he must learn to dance or skate. It can only be done by continuous practice, sometimes lasting for months, or even longer with very "tense" people. In addition, one who is learning to relax must do his homework, practicing by himself for an hour or two each day.

Does this seem a long and tedious training? If so, it must

be remembered that it is a lifetime's habits that are being changed. How difficult this must be can be seen in the case of ordinary speech. Speech is nothing but a complicated group of habits. When once we have formed them, it is almost impossible to replace them by others. Few who have learned a foreign language after growing up are completely without accent in it. The old habits are too hard to shake off.

How does Dr. Jacobson know when his pupils have learned this formidable lesson? Experience has taught him to look for certain signs. A person who is thoroughly relaxed has a special toneless appearance, almost as though he has been drugged. Breathing is regular and even, there is no swallowing, the eyelids are motionless and look toneless. All slight fidgeting movements are gone, and there is no swallowing. The pulse rate often slows. Most important of all, the electrical apparatus, which Dr. Jacobson has devised, records no "action currents" from contracting muscle fibers, although this test can of course only be made on single muscle groups.

A subject in this completely relaxed state, which is only reached by trained people and not always even then, reports that thought of all kinds has gone. He cannot do simple sums in arithmetic, imagine himself walking or talking, imagine a walking man, the Eiffel Tower, or any other stationary or moving object. When he does imagine such things, the tensions come back, in the eyes, the arms or the legs. When he does "mental problems," such as counting or multiplication, or answering questions like "What is probability?", he reports that tenseness is present, generally in the speech muscles. The reports were verified by the

electrical test. One relaxed subject was asked to imagine pumping up a bicycle tire. The electrical apparatus recorded a rhythmical contraction of the biceps. The muscle fibers had invisibly contracted as though he were actually pumping. But fewer of them contracted, and the contractions were smaller.

Another experiment revealed that when a person *imagined* counting "One, two, three," there were slight muscular contractions in his tongue.

A third experiment showed that when a person was asked to imagine bending his right arm, muscular contractions occurred in his right eye muscles as well as in his right arm.

From these remarkable experiments you can make a rule:

> "When you are relaxed, you are not thinking.
> When you are thinking, you are not relaxed."

Once more, Man cannot escape from action. Child of a hundred million years of things that *move*, he still retains vestiges of his ancestry, even in his own special activity of quiet thinking. When he is brought into contact with circumstance, even in thought, he must pay his tribute of action, even though he makes a token payment only. Movement, slight indeed but visible through the proper instrument, is present in all thinking.

Jacobson finds that voluntary relaxation may also cause the involuntary muscles to relax. These "smooth" muscles of the internal organs, the lower part of the gullet or esophagus, the intestines, and so on, are ordinarily not under voluntary control. In certain kinds of nervous disorder they "go into spasm." That is they semi-permanently

contract, often causing trouble and distress. This seems to happen in the disease called mucous colitis, and Jacobson gives interesting X-ray pictures showing how, after long training, the "spastic" intestine has relaxed. The health of these people was greatly improved.

So that relaxation seems to affect not only the voluntary muscles, but also the involuntary ones, which are difficult to control in any other way. What effect, if any, this may have on thinking we do not know. Except that these "smooth muscle" spasms often accompany fears and other unhealthy emotions, which are apparently removed by the treatment.

That brings us to a further result of prolonged training in relaxation. People under complete relaxation found that emotion, such as worry or fear, disappeared. When they were asked to keep their worry or fear with them, and at the same time to relax, they could not. *Either* worry *or* relaxation was present. Both could not be.

This brings us to another rule:

> "If you are worried, you are not relaxed.
> If you are relaxed, you are not worried."

and:

> "If you are afraid, you are not relaxed.
> If you are relaxed, you are not afraid."

Remember that emotion is a frequent source of motivation in thinking. Once again, the worrier is exactly the man who is unhealthily motivated by fear to think. When he goes to bed he doesn't sleep but thinks how terrible it will be if he has made a mistake in the day's work. He'll

have to get to the office early tomorrow and find out. Or, the boss looked away from him in the elevator; wouldn't it be dreadful if "they" intended to fire him; would the firm across the way have a job that might do?

Unless you are one of those fortunate people who never worry, you must have had thoughts like this. They are all motivated by fear; and Jacobson's results seem to show that fear does not exist without muscular tension.

So that not only thought itself, but in these cases its motivation also, seems to go with muscular tension. When the tension is removed, thought and motive both go.

MOTIVE AND MUSCULAR TENSION

Is all motivation accompanied by muscular tension?

Psychology is not yet in the position to give a full answer to the question. However, there are a few things we do know. The great, elemental food-motive is accompanied by muscular action. When you are hungry, the smooth muscles of your stomach are contracting. This is shown by swallowing a child's balloon which is then inflated and connected to a device for recording pressure. When a fasting man signals that he feels the pangs of hunger, the indicator moves, showing that his stomach muscles are contracting. Certain self-sacrificing souls have gone to sleep after swallowing such a balloon. During the night the indicator moves from time to time; shortly after, the sleeper stirs. Similarly, hungry animals are notoriously restless. A hungry (or thirsty) rat will go into a squirrel cage leading to his living quarters and run "like mad," as a student said.

Thus these elementary motives at least are accompanied by action and tension.

What of the more complex motives such as ambition, or the minute-by-minute ones which cause us to shut the door or go to find the car key? We do not know as yet whether these also are accompanied by tension. There is, however, some evidence that tension is present when we are motivated to do such things as add a row of figures. In general, however, except for emotion we know little as yet about the relation of motive to tension.

THE GOLDEN MEAN

When we do anything, it is important that the right muscles are contracted, and to the right extent. If the wrong muscles are contracted, however slightly, or if the right muscles are contracted to an unnecessary extent, the "style" is spoiled. Everybody who has studied voice production knows that for best effect the correct muscles must be contracted to the proper extent, and others relaxed. The singer learns that with the proper muscles properly relaxed, little effort is required from the breathing apparatus for the voice to reach the back of the house if the accoustics are good. The same thing is true of the speaking voice. Teachers of both speaking and singing stress relaxation. They mean, of course, that the correct muscles should be contracted, the others left relaxed. When a person becomes excited, the voice is apt to rise in pitch and become "shrill." This seems to be due to unnecessary contraction of muscles. In fact, whatever physical activity is being taught, a teacher who knows his job will stress relaxation. Whether

it is tennis, where the best strokes can only be made with the proper balance of contraction and relaxation; whether it be golf, where the same rule holds; or boxing, where the man who contracts wrongly "pulls his punches"; ballet, where the "effortless" ease of the skillful performer is obtained in the same way; acrobatics; piano playing, where a genius, Tobias Matthay, revolutionized the theory of performance by relaxation exercises—whatever the physical activity, the same thing is true. For efficient performance, *only that degree of muscular action must be used which is essential for the purpose.* When the performer breaks this rule, his performance becomes "throaty," "wooden," "clumsy."

So another rule comes out: *For any physical activity, there is an optimal muscular activity, involving the correct muscles and the correct amount of contraction.* If there is too much contraction, or contraction of the wrong muscles, the work is spoiled. If there is none at all or not enough, the work is inadequate on the other side.

Now since thought has grown up with action, and has grown out of it, one is not surprised to find that the same rule holds good with thinking.

For every mental task, *there seems to be for each person an optimal contraction of the muscles.* If there is no muscular action at all, thinking is impossible. You will remember that "if you are relaxing you are not thinking." On the other hand if there is too much contraction, thinking is impeded.

This comes out in simple performances. Dogs were made to pull a cart containing different weights. As the weights were increased up to a certain point, conditioned reflexes ("associations") previously acquired were strengthened;

beyond this point they were weakened. People, again, were required to squeeze grip-handles while they memorized lists of nonsense syllables; the strength of their grip was observed on an indicator. They did their best learning at one pressure; above or below this, learning was less efficient.

The rule seems to hold good also for more complicated activities. Experiment has shown for instance that when people were engaged in tracing out a star which they could not see directly, but only in a mirror—a task which required concentration—the performance of seven out of ten dropped as leg tension increased. "Mental arithmetic was seriously disturbed." G. L. Freeman thinks that the more complicated performances are more easily disturbed by over-tension than the simpler ones. You must have muscular contraction, but not too much.

Some people find they do their best mental work pacing up and down the floor, or in a not too comfortable chair, one which requires effort to sit in. The chapel of an old college at Oxford has seats under the regular ones. They are small, and so made that one must use a distinct effort to sit on them without falling over with a crash. It is said that monks who had fallen asleep during Mass were forced as a penance to sit on these small seats. I have sat on one of them, and I know that they would cause a monk to make that amount of muscular contraction which would keep him thinking about something, at least. Freeman used a very similar method to induce tension in one of his experiments!

We saw that Helmholtz used to like to walk in the country when he was thinking. Others have said they do

their mental work best when at concerts or at church, where there is still some muscular contraction necessary in order to sit up straight. Sometimes a solution to an inventor's problem comes when he is doing other work, or reading a newspaper. Here the thinker is indeed contracting his muscles, but is not directly engaged on the problem. Each individual seems to have *his own* optimal degree of contraction for mental work and possibly for different kinds of work. In every case, muscular tension there must be, or he is not thinking. When engaged in composition, Beethoven used to shut himself in his room, and shout and rush about like a madman. Others think best with the minimum of tension, lying in bed.

The rule seems to be then: *make sure that during your mental work you are not using unnecessary muscular tension.* Watch your friend who seems to do his work without any effort. He may indeed be specially gifted, and is likely to be a person who can do more work than most people with less fatigue. But the difference between you and him may not be that he is more gifted than you are. You may have got yourself into habits of wasteful effort, and be actually impeding your thought. Beethoven's work was intensely emotional, and he may have needed the extra fillip of intense muscular action. But neither you nor I are Beethovens!

HAS MUSCULAR TENSION DURING THINKING ANY USE?

Some psychologists think it has not, but is merely a by-product of thought. They believe that during thought there

is a nervous overflow from the brain, which puts the muscles into action. According to these people, when a person fidgets, either by fingering a button on his waistcoat as Sir Walter Scott used to do at school, or by swinging his foot, or by otherwise tensing his muscles, nervous impulses are, so to speak, splashing out of the brain like the water out of a sink when the tap is open too far.

On the other hand, Dr. Freeman believes he has shown that the tensions—that is, the right kind of tensions—are a real help. He believes that they reinforce thought, by sending up to the brain nervous impulses which assist thinking. The same effect is seen when a runner grips a cork in order to improve his running time, or when the knee-jerk, a test taken of every candidate for the air force, is increased by clenching the fists. It is difficult to be certain how this works. But Dr. Freeman gives much evidence for his explanation, which does seem to be more reasonable than the "splash-over" theory.

It would be surprising to find that such a universal activity as muscular action during thinking was not only a useless by-product, but actually wasteful. It is, however, true that we do in fact inherit a number of leftovers, which were useful to earlier forms of life but are no longer functional. The possibility should then be borne in mind that muscular tension during thought *may* be a similar vestige from the all important action of our remote forbears.

Thus as William James once said, "We think with our muscles." Nature has thrown over the pale cast of thought a subtle net of muscular activity from which it can never wholly escape.

THE THREE KINDS OF TENSION

Actually, three different kinds of muscular tension seem to be present. There is first a general overall tension over the whole body. This seems to show a daily rhythm, being greater at night than immediately on waking in the morning, and corresponds to a similar rhythm in the efficiency of thinking. One psychologist has found, for instance, that work done just before going to bed was 6.5 per cent better than that done in the morning just after waking. (This may be due to other reasons.) With practice at any particular task this general overall tension grows less. Everybody has seen the small boy first learning to write. How he twists his face, screws his head sideways, purses his lips! As he practices, the unnecessary tension grows less and less, until a good, "easy" writer uses a minimum of tension. The beginner at any physical activity is generally "clumsy." That is, he contracts muscles that should not be contracted. The beginner at any mental task is apparently clumsy in the same way; and also in the same way the unnecessary muscular contractions drop off with practice. As the "score" goes up for mental work, tension tends to fall down. Fatigue also tends to increase tension. (Although the evidence is not quite clear on the latter point.)

As well as this general muscular tension there seem to be special tensions for special mental tasks. People were required to do such things as adding or subtracting figures, counting the "a's" in a passage of print, solving jigsaw

puzzles, performing a general information test. When asked to do their best at these tasks, they almost always tightened a certain muscle in the leg.* These special patterns of tension are thus quite unrelated as regards their location to the mental activities going on. When a person is doing mental arithmetic, it is found that this special pattern is incessantly and delicately changing.

The third sort of muscular tension is in a part of the body directly related to the thinking. This has already been described. Tension in the arm when thinking of inflating a tire, or of turning an ice-cream freezer, belongs here. Dr. Jacobson found indeed that an amputated man contracted the muscles of his good leg when he thought he was imagining motion in the amputated one (which he could do quite easily)!

Science has not yet finished with the task of examining these and perhaps other kinds of muscular tension. The three types, general tension, special tension unrelated to the thought, special tension related to the thought may be revised. But enough has been done to make it certain that we do indeed "think with our muscles."

HOW ARE MUSCULAR TENSION AND "NERVOUS TENSION" RELATED?

This book is only indirectly concerned with the problem. But the question is so important that a few words are in order. Jacobson and many practicing physicians

* The *quadriceps femoris*, one of the muscles moving the thigh. (Freeman and also Golla.)

have found that the nervous person is often more tense than the more stable one. Relaxation does very often bring relief *in some forms* of nervous suffering. It used to be said that no pupil of Tobias Matthay's school for piano playing ever had a nervous breakdown. Nervous trouble used to be not uncommon at other schools, which is not surprising in view of the very concentrated work necessary to make a concert pianist. And it is certain that daily practice in relaxation, such as Matthay used, would tend, in many cases, to relieve "nervous tension."

We know further, from common observation, that the "nervous" person is apt to be "jumpy," and experiment confirms this. We know that relaxation does diminish "starts" to sudden noise. The nervous person often has pains for which no physical reason can be found; we know that pain may be diminished by relaxation. The nervous person sometimes has feelings of pressure at the top of his head. We know that this may often be removed by relaxation. And so on.

It adds up to this. In many cases *the nervous person is more tense than other people. Many of his symptoms may be directly due to his tension.*

Possibly his thinking also may, in some cases, be impaired; for we also know that overtension may impair thinking.

If you are interested in the relation of tension to nervousness, by all means read Jacobson's book *You Must Relax!* The writer has discussed the question in a book called *The Story of Man's Mind.* He would like, however, to warn the reader that in his present opinion the problem is not as simple as he then thought it!

From what has been said in this chapter, these principles and rules seem then to emerge:

1. Thinking and action have in the course of evolution been closely connected. Thinking is still in most cases part of something a human being does to his surroundings. Thought still works in a setting of action.

2. Even during the time when we are apparently thinking quietly, without moving, our muscles are still acting.

3. Thought is apparently impossible without this invisible action. If you are thinking, you are not relaxed. If you are relaxed, you are not thinking.

4. The same is true of emotion, that potent motivater of thought. If you are angry, resentful or afraid, you are not relaxed. If you are relaxed, you are not angry, resentful or afraid.

5. For best thinking, there is an amount of tension that is best. Not too little, which may cause you to stop thinking. Not too much, which may impair your thinking. See that you do not use too much.

6. If you are "nervous," you may be over-tense. In that case, learning to relax will probably help you. It may help your thinking, if only by making it possible for you to think with less fatigue.

10. THOUGHT AND LANGUAGE

TWO PEOPLE ARE TALKING

READER, take a look with me at something which has changed the history of the world. Something so revolutionary, so novel in the long history of life on this earth that it could hardly be imagined if it had not taken place. Something so recent in the history of living things that in spite of its earth-shaking importance its ultimate form has not yet been determined. Take a look at this miracle with me. Like the bluebird, you may find it in your own garden if you look long enough.

Two people are talking!

Language is the marvel that has built and pulled down empires, has built up civilizations, made cultures, sent countless hosts to their death and bidden others live. In its more exact form as mathematics it has made science possible, and may yet enable scientists to destroy the globe itself.

It is so close to thought that *we can hardly tell where the one begins and the other ends. Like adjoining country estates, the two "march" side by side, with often little or no distinguishing mark between them. In the history of mankind they have grown up together.* During much of the time we are speaking aloud directed thinking is un-

doubtedly going on. In fact, many have said that thought is language, spoken or silent. But psychologists have shown that this is not so. For instance, we do indeed generally move our tongue when thinking silently in words, but the movements do not as a rule correspond to the words we are thinking. We can acquire a "general concept" without being able to put it into words, and so on. Other instances will come later in this chapter.

WHAT THE TALKERS ARE DOING

Those scientists that study language and call themselves philologists, tell us that we do not need many different noises to make a spoken language. People using different languages may choose from fifteen to thirty of them; the philologist calls them phonemes. A native of Chicago who speaks standard English uses about thirty-two. Whenever he is speaking the thirty-two phonemes stay the same, with little change. They may be thought of as the atoms of his spoken speech, corresponding to the atoms which make up the physical world, except that they are about a third as numerous.

With complications which I omit, the speaker builds the phonemes into higher units or morphemes, which have a constant meaning. (The chemically minded reader will think of the molecule, which is a combination of physical atoms.) In the sentence *Poor John ran away* we are told that there are five such morphemes.* These are the first

* There are 11 to 14 phonemes; this means that in this simple sentence we use a third to nearly a half of all the sounds employed in English.

three words, *poor*, *John*, and *ran*, together with two making up *away*, namely, *a-* and *way*. Out of the morphemes, in turn, the speaker builds words, phrases, sentences, paragraphs, unities upon unities. Out of the paragraphs he may build still higher unities. When a great orator makes an hour's speech, he fashions a carefully balanced unity of exposition and emotion, an architectural structure, with delicately poised paragraphs, built from delicately poised sentences, made out of words and morphemes, in turn made out of no more than thirty-two simple noises.

How does he do this almost fantastic thing? I do not know. But this I know. He could not do it without the cortex of his brain, that superlative organ which nature gave to man in its human form a mere yesterday in the history of life. If you remember the chapter on the unity of thinking, you will surely agree that, to use the expressive term, the cortex *has got what it takes*.

But this is only the beginning. When the orator is making that speech, he is using parts of his body which, in the total history of the race, are sheer amateurs! His lips are moving. Animals have lips, but animals cannot speak. For millions of years before man arrived, they used their lips for eating. "Take those lips away!" and the orator cannot talk well, it is true. Neither can he drink his soup well! So it is with tongue, teeth, larynx, diaphragm. Our non-speaking forbear, the animal, had other, essential, uses for them all. Travis, an authority on the psychology of speech, tells us that man, the talker, has not developed a single group of special muscles for the very special activity of speech. He gets his speech muscles second hand. He puts to his own use what his forbears, the animals, have be-

queathed to him, and now makes them do double duty. Since the muscles cannot do two different things at once, they have to change over from one organized control to another when you start to talk.

"Johnny, don't speak with your mouth full!" says the mother at a million tables. It is good advice and good training. Because when Johnny tries to talk with his mouth full of toast, he not only speaks badly but swallows his toast badly.

When the orator speaks, then, all these muscles must do a more delicate job for which they were not designed, and do it as a team. He stops his lungs breathing in the ordinary way, and breathes according to a special "speech-rhythm." He checks his tongue in its work of gently moving the saliva, and with it begins a delicately co-ordinated speech-dance. He checks swallowing. Through the muscles of his face he moves his lips to the precise and fleeting position required to make the exact sounds he needs. And so on. If he misses out on the timing or the accuracy of but one of the structures, his audience will complain that he didn't speak clearly. Or perhaps, if they are less charitable, they may say that he "had a drink too many." We know that the first effect of alcohol is to cause a slight lack of co-ordination in the finer adjustments, and we recognize the sound of a man who has taken a little too much of it.

The orator directs all these microscopically adjusted movements through the cortex of the brain. It is one more job for the statistical shoulders of that noble machine. We know where the cortex does the job. A master switchboard is located in what is called the "speech area," on the left side for right-handed people, and *vice versa*. From it

nervous impulses are sent out which, instant by instant, control the whole apparatus, causing certain lower "centers" to go into operation exactly as necessary, others to suspend activity. This is the center of intensest activity when we are speaking; but the whole cortex is probably active to a lesser extent.

So much for the production of sound. But the orator is doing far more than this.

In the small sea-side town where I lived as a child the sailors used to bring home parrots. Some of these birds had an extensive vocabulary. I used to be delighted by Captain, who lived at the coast-guard's house. (Captain later laid an egg!) Captain would shriek, "Get busy, you lazy son-of-a-gun"! "He" would also roar: "Ahoy, there," and other nautical salutations. We used often to go round to hear Captain "speak"!

That was because we didn't know any psychology. For, strictly speaking, *Captain never spoke* any more than a phonograph really sings. Captain repeated sounds. He parroted. Although we used to think that Captain "knew what he was saying," it is certain that what "he" did was to produce certain sounds when the right stimuli presented themselves, much as a dog will "shake hands" when he hears certain words, or "speak" when he is told.

There is a difference here. Captain made articulated sounds, the same sounds as his namesakes the world over, but "he" did not talk about anything. In his utterances Captain did not refer to "what the words were about." The parrot's utterances were, again, learned responses, set off by the situation in which he found himself at the moment.

Psychologists have given various names to this difference.

A simple way of describing it is to say that such utterances lack the *reference function.* That is to say, when the bird talks he does not refer to the meaning of the words, but merely goes through a mechanical performance related only to the immediate surroundings.

In contrast, human beings talk *to* somebody *about* something. It is the intimacy and the complexity of what we do here that makes our performance unparalleled in nature. The orator, and we are assuming that he is a great orator, is making certain delicately timed and balanced sounds. In addition he is talking with reference to a complicated series of events in the great world, events which are not affected at the moment by the fact that he is speaking about them. When Lincoln said, "Four score and seven years ago our fathers brought forth on this continent, a new nation," what the Fathers had done was not affected by what the great Liberator said. Nevertheless there were things going on in that great brain which corresponded to the fact that the speaker was talking about those events of history.

Leaving the reference function, which has been called by other names, there is still the fact that the speaker speaks *to* somebody. This also has its counterpart in the brain processes. A person talking to himself behaves differently from an ordinary speaker. Speech is different according to the listener.

A young man has had a traffic accident. "I smashed the car," he says to his father over the telephone right after the accident. He says the same words to his school friend next day, but he says them differently. The responses in each case may be expected to be different also. Psychologists have called the third factor, that of talking to or with

somebody, by the name of *evocation.* It also has its corresponding brain processes.

At this point a warning is in order. Psychologists have found it useful to distinguish these three factors in speech, which we have called utterance, reference and evocation. That does not mean however that the speaker has to do three separate things when he speaks and then put them together—any more than a builder has to make the inside and outside of a window pane. The speaker behaves in a certain very complicated way towards another human being. Since this behavior is so complex and important, it has been found worthwhile to distinguish three aspects of the activity. But please remember that while psychologists do indeed find the division useful I would not want you to go mystical about it and conclude that it is anything more than a scientific convenience.

DISTURBANCES OF SPEECH

Like any other action of our body, speech behavior may be disturbed. Then you have what is called speech pathology. Everybody has seen some of these cases. For instance, when *utterance* is disturbed, you may have such conditions as stuttering, and in milder cases, lisping. When you remember how complicated the production of speech-sounds is, you will not be surprised that such a disorder as stuttering has been attributed to a variety of causes. Anything that disturbs a link in the chain will disturb speech production. Experts have blamed such things as wrong breathing, faulty balance between the two halves of the

brain, emotional disturbances, and so on:

On an old-fashioned sailing ship, a man fell overboard. The mate came running up to the captain.

"B . . . B . . . B . . ." he began in great excitement.

"What?" roared the captain.

"M . . . M . . . M . . ."

"For heaven's sake, sing it, man."

"Overboard is Barnabas
Half a mile astarn of us,"

sang the mate without difficulty. Many stutterers can sing when they cannot speak. That is sometimes said to be because the stutterer can breathe correctly for singing while he cannot do so for speaking. It shows that there is nothing wrong with the structures by which he speaks, but only with the way he uses them. I have seen an apparently hopeless case completely cured when certain emotional conflicts were cleared up. Each case must be judged on its own merits, however, and a speech expert is the only person who can do this.

There is a much more serious disturbance, which throws light on the part speech plays in the thinking of the normal man. When a person has a stroke, caused by the breaking of a blood vessel in certain parts of the brain, or suffers a head wound in the same region, he is often afflicted with a condition called *aphasia.* According to the place and the severity of the injury his speech may be disturbed in a number of different ways. Sometimes his production of speech is disturbed. He may be limited to a few words, such as "Yes" or "No."

A lawyer in a Nova Scotia town walked out one morn-

ing to go to his office. On the way he passed a lady of his acquaintance, who remarked that it was a beautiful day.

"Damn!" said the lawyer.

During the night he had had a "stroke," and had happened not to speak to anybody before he went out. The aphasia had affected his speech-utterance, and left him—all unknowing—with only one word. This kind of aphasia has been given various names. It is sometimes called *verbal*, sometimes *expressive*, sometimes *motor*, aphasia. In this case and others like it, a man may know perfectly well what he wants to say, but be unable to say it. In this kind of aphasia *utterance* is affected. The reason is that certain centers in the cerebral cortex have been damaged. Damage in slightly different places will affect the *reference function*. When this happens, the patient may have no difficulty in making the correct sounds, but cannot use them to express meaning. For example, some, though perfectly well able to say the name of an object, cannot give the name when shown the object. An officer from the first war had been wounded in the left side of his head.

"What color is that?" asked the specialist, pointing to a blue object. The officer struggled, but could not say the word.

"Would you mind pointing to the door?"

Only with great difficulty could he do this. Again, he found it hard to connect object (door) with name. It was apparently a major intellectual feat for him. Sometimes such patients cannot succeed at all in this simple task. Yet Dr. Head, whose work on aphasia is a classic, tells us that "direct *viva voce* expression is not affected" in these cases. They cannot play cards, because this needs recognition of

names, and power to add up a score. Yet they can often play chess and draughts (checkers) correctly, but probably could not tell you the name of a pawn if asked to do so. This kind of speech disturbance was called by Dr. Head "nominal" aphasia, because the patient loses the power to use names and symbols. It is a disturbance of the *reference function*, and is sometimes called "amnesic" aphasia.

And finally, evocation may be affected, in what is called "receptive" or "sensory" aphasia. These patients cannot understand what is said to them, although they may be able to speak rationally themselves.

CERTAIN KINDS OF THINKING REQUIRE WORDS, OTHERS DO NOT

A schoolteacher says to a class: "We'll have some mental arithmetic. How many are thirteen times six?" At once the children begin to move their lips. They are using some kind of formula, such as: "Six times three are eighteen, eight and carry one," and so on. Head has shown that to do arithmetic a man must be able to put words together in a meaningful whole. When this ability is gone, as in some cases of aphasia, the power to do mental arithmetic is gone also.

On the other hand, some of our thinking does not require words at all. Remember the officer who could not name colors, nor play cards but could play chess. He could not think in language, but he could think where language was not necessary. Aphasics have been given mental tests which

require considerable thought. Some who could say only one or two words have done very well in them. For example, one who could say only "What" and "No," and hardly ever produced anything but a grunt, scored above the average, though it is true that he was slow. On a mechanical aptitude test he was about at the level of the ordinary man in the American army.

An eminent statesman, we are told, went about his duties for half an hour after his stroke, thinking clearly on various subjects.* He did not find that he was aphasic until he tried to speak. One famous patient, Dr. Saloz, recovered and could tell his experiences. *He was totally unable to speak, could not hear words, and could not write.*

"I knew exactly what I wanted to say," he said, but he could not say it.

There are even cases where speech is present though confused, while the thought is unaffected. For instance, a man doing arithmetic may say "*seven times nine are fifty-six*," "mean" sixty-three, and perform the sum correctly, as thought he *had* said sixty-three!

I would not want you to think that the problem of aphasia is by any means settled. It is not. But patient and skillful men have been watching these unfortunate people for eighty years or so. The gradual insight they have attained does seem to make it clear that language and thought are two different things; that some kinds of thinking need language, others do not. †

* Foster Kennedy and Wolf.

† K. L. Smoke has shown that generalization can be achieved without words. Of course, our more exact thinking is done by words in language and the improvements of it which we have devised, e.g. mathematics.

LANGUAGE IS OUR TOOL. HOW WE USE IT

Like imagery, *language whether spoken or written is a tool of thought.* It is the best tool we have. When it is damaged, certain kinds of thinking are damaged, others need not be much affected.

How do we use this unique human tool, and what advantages does it give our thinking?

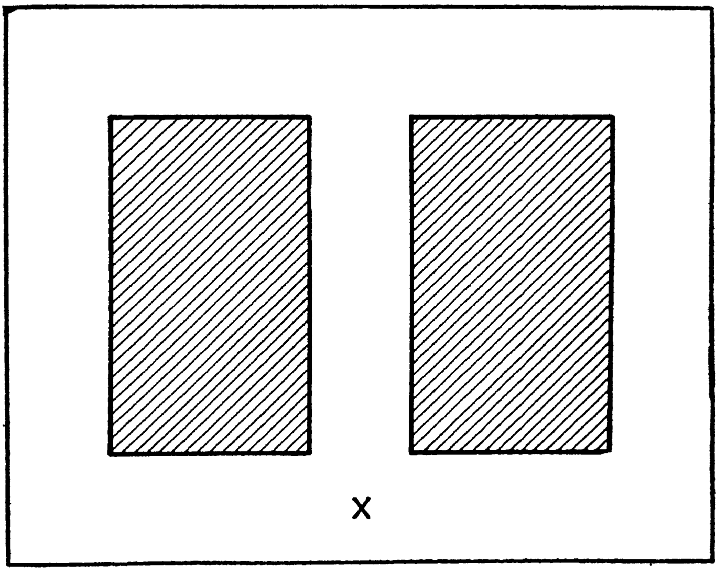
Its value is incalculable. By using speech, a modern man can communicate with others, and learn from their experience as well as his own. By written language man can put into permanent form the products of his deepest and most exact thinking. The great library of Alexandria was called the soul of the human race. The invention of printing multiplied the power of words almost to infinity. Anybody who wishes can now follow the carefully worked-over thought of the philosophers Plato and Kant. If he wishes, and has the ability to learn the special kind of language called mathematics, anybody can follow the peerless Newton or the great Einstein. Man has used the special language of mathematics to control and to understand nature. He is beginning to use it to control and understand the greatest riddle of nature—thinking man himself. More and more, the physiologist, the medical man, the economist, the psychologist, are using the exact thinking that mathematics makes possible. Without language man must rely on his own experience. With it, he can draw on that of all the past, and at the same time sharpen and strengthen his own thinking to an incredible degree. Thereby he has in an unparalleled

way improved his techniques of dealing with nature and with his fellow man.

It is difficult to show experimentally the power of a gift so stupendous as that of speech. The experimenter seems almost to be dazzled by the brilliance of this human achievement. Here are a few examples of the first beginnings that have been made.

ONE WAY IN WHICH THE HUMAN BEING USES LANGUAGE

A fine experimenter, Walter S. Hunter, put rats in a maze where the path tc be run was in the form of the figure 8, with rectangular blocks forming the two halves. By vari-



ous methods he and others following him have tried to set up what is known as "double alternation" in such a maze.

How does a human being make out when confronted with a similar problem?

He uses language, but in such an elementary way that it sounds almost laughable. An adult or an older child needs relatively few trials. He puts the solution into words, such as: "Go twice to the right, twice to the left." Then he has it! That is, he uses a *method*, the method of language, that is completely beyond the animal's capacity. And remember, in the ordinary maze, so constructed that the verbal method cannot be used, the human being is not so much better than the rat! One experimenter found that blindfolded adults, children, and rats took about the same number of trials to learn ordinary mazes. Of course it is not only the ability to use language that makes man superior, but the possession of a better brain, that can at the same time use the more difficult tool.

In general, even when there are no repeated turns as in the figure 8 maze, the human being is apt to learn tracing mazes (they must be threaded by the finger or a metal pencil) by using language. In one experiment those who employed speech needed only a quarter of the trials required by those who learned "by the feel of it." Some kinds of generalization have also been shown to be helped by language.

It has been found that verbal instruction improves the scores in the stylus, or metal-pencil, maze. Of course! In general, a human being *can* learn any maze without language, but, when language can be used he does a better job with it. Psychologists have definitely shown that there

are certain kinds of skill which cannot be described exactly in words. Here instruction beforehand does not help. And there are manual skills where the verbal method cannot be used, or where human beings prefer not to use it. I myself would prefer a surgeon who had not learned his skill from a correspondence school! "Conditioning" experiments involving language have been performed. But all in all, the psychologist has to apologize for the experiments on the value of language in thought. If I am to be honest, I must say that in face of the shattering power of this human invention, they do not amount to very much!

For it is indeed shattering. It is so new in the history of living things that we cannot yet predict its consequences. Think of the powerful creatures whose rule has preceded ours on this planet, and which have given place one by one to the undisputed master of the world, *Talking Man!*

The ancient Jewish prophet Elijah in his cave on the mountain cried: "*I, even I only, am left; and they seek my life, to take it away. . . .*"

And behold, the Lord passed by, and a great and strong wind rent the mountains, and brake in pieces the rocks before the Lord; but the Lord was not in the wind; and after the wind an earthquake; but the Lord was not in the earthquake:

And after the earthquake a fire, but the Lord was not in the fire; and after the fire a still small voice.

. . . And behold, there came a voice unto him and said, "What doest thou here, Elijah?" . . .

The Lord was in the still small voice.

11. THE UNIVERSALITY OF THOUGHT

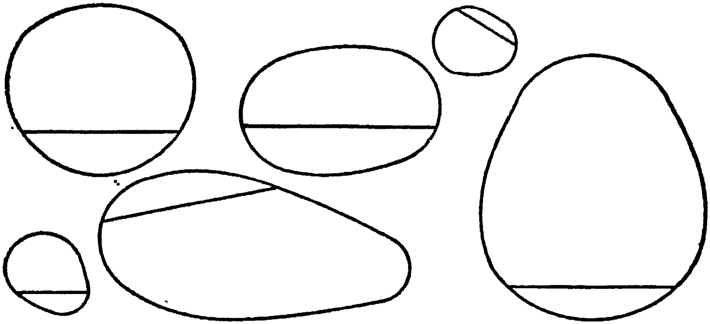
SOME time ago I said that we ordinary people are like spectators at an athletic contest. We can look at what the great thinkers have done and then go home and do the same sort on a smaller scale. If you will let me put your brain through a few paces I will show you an instance of this. What you are going to do is simple enough for anybody with the equipment of the average human being. You are doing things like it every day and indeed almost every moment. Yet, although it may seem trivial and even inconsequential, it repeats on a simple scale the achievements of the greatest thinkers. And it has been the subject of bitter and indeed bloody controversy through the ages.

With your co-operation, I am going to have you make a generalization and develop a concept. It is generalized thinking that gives science its uncanny power over nature, and has enabled man to lift himself out of the cave. The greatest thinkers have thought in universal terms; and yet here again they have done no more save in degree than you do every day. In order to show the Universality of your own thought I shall employ a simple form of a well-known laboratory method. I shall invent an entirely arbitrary and mythical kind of figure, to which you will learn to attach a name. The name must not mean anything to you, for that would import the wrong ideas into your

thinking. The psychologist calls this kind of name a "nonsense" term; the nonsense syllable has been much used in research on memory as well as on generalization.

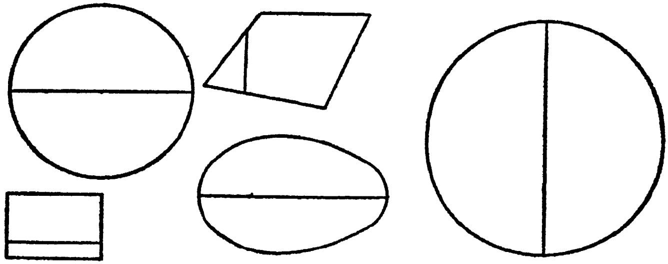
One such name will do as well as another; but let us call our figure—perhaps ridiculously—a *Zobble*. You will find six Zobbles just below.

These are Zobbles.

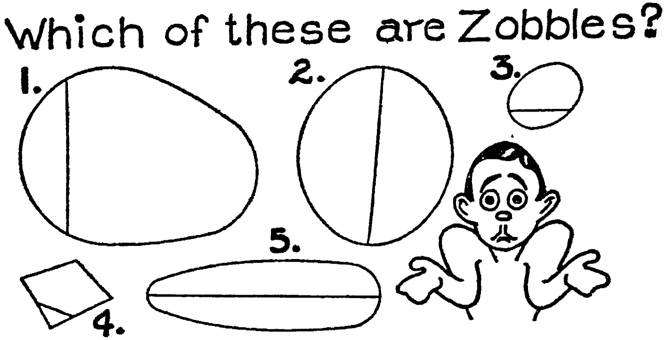


There are figures which look like Zobbles, but are not, and it is important that you should be able to recognize these also. Take a look at these "false" ones. None of them are Zobbles.

None of these are Zobbles.



Do you think you would know the genuine thing now? Could you pick out a Zobble in a line-up? Here is the line-up. Which are Zobbles?



It's easy enough, of course. Numbers two and five are ruled out because they are divided into two equal parts; number *four* is out because it is enclosed by straight lines instead of a single curve. Only one and three are Zobbles.

A Zobble is a figure enclosed by a single smooth curve, and divided into two unequal parts by a straight line.*

Now see what you have so easily done. I think you will be surprised when I draw up the list.

(1) *All the Zobbles are different.* (The six you first saw and the two in the line-up all differ in some respect, shape, size, position of cross line, or what not.)

(2) *All the Zobbles are the same.* (They are bounded by a single smooth curve, and are divided unequally by a straight line.)

* The artist, Mr. Don Nixon, rightly points out that I should technically add here ("with no re-entering part"). This would necessitate a corresponding addition to the false Zobbles.

At this point you may become impatient. Because this will seem to be elementary nonsense and playing with words. But please wait a moment.

What you have done is to *generalize:* And you are in good company if you are annoyed. For people have been getting furious about generalization for over two thousand years. Noses have been bloodied, heads broken and even throats cut over these two sentences, or something very like them. Already in the twelfth century a monk was saying of generalization: "The world has grown old treating of it, and has taken more time for its solution than the Caesars took to conquer and govern the world." Generalization has been a fighting word since Plato, precisely because it easily begets verbal contradictions which seem elementary but really spring from profound difficulties.

(3) When you make this simple generalization, you separate what is the same from what is different. The psychologist says that you *abstract* from the differences. This abstraction is an immensely important part of your thinking and mine. Without it we human beings would be completely helpless. We could not live together, develop our science or our arts, enjoy our normal mode of life or use our language. Even our less favored friends the animals need it in a simple form to get their food, and to ensure their survival in many other ways.

(4) In addition, you have connected a number of different figures under one "idea." The psychologist says that you have formed a general concept.

This might seem enough! But the tale is by no means told. There are three more things you have done.

(5) You have learned to use a general name. It was

riots over the relation of speech and the concept that in the end brought so much trouble to the brilliant thinker Abelard at Paris in the twelfth century.

The next has compelled wonder rather than anger over the ages. It has fired the imagination of poets and philosophers since long before the birth of Christ. Theories of Heaven, of the mind and of the nature of knowledge have been built upon it. It *is* an astonishing thing.

(6) You have given yourself the power to deal with an *infinite* number of things at an *infinite* number of places and of times, past, present, and future. An infinite number of figures can be drawn according to the specification. They may be of all shapes and sizes. They may be in Cleopatra's tomb, on the other side of the moon, or at the south pole. Your single concept includes them all.

The final thing has brought neither anger nor wonder, but something which in the steep ascent of man has proved more important than either. It has brought power. For good or ill, the power of modern science rests on it.

(7) You have made yourself able to predict. Whenever, wherever the correct figure is drawn you can say that certain things must follow. It is possible to show by geometry that certain things are true of all Zobbles. However, a simpler instance will do, though, again, it may seem trivial. Whenever one of your Zobbles is cut out and then sectioned along the dividing line, the one part will weigh more than the other.* This was true in 1066, when William the Conqueror came to England. It will be true in 2066 of the

* A more precise statement would be that if a Zobble drawn on a sheet of uniform thickness and mass is cut out and sectioned along the dividing line, the two parts will be of unequal mass.

picture of Humpty-Dumpty in the British Museum copy of *Through the Looking-Glass*, if somebody draws the right kind of straight line across him, and cuts out the oval.

It is on prediction that man's immense power over nature rests. The engineer knows that the dynamo he has built *will* (in the future) generate just so much current when certain connections are made. The *Nautical Almanac* is unlike all other "histories" in that it lists day by day, hour by hour into the future what *will* happen at specified times to the stars, the sun and the tides. It is a chronicle, but a chronicle of the future, and from it the sailor and the aviator derive power to navigate the waters and the air.

With these three last things you have touched the very heart of scientific thinking, as practiced by all scientists from the greatest to the least. The scientist must name. Chemistry, for example, could not exist unless the elements and compounds had been given names. (The numbers now attached to elements are a special kind of name.) The scientist must think universally. Remember again that when the forty foot pump would not work, the wag Galileo reputedly said that "Nature apparently abhors a vacuum only up to thirty feet." This was his way of saying—among other things—that a law of nature must be universal, and that the scientist must think universally. The scientist must be able to predict. Otherwise his science cannot be applied, and will exist in a prison.

You will still be wondering why people quarreled about all this. The disputes have now become a matter of history and arose partly because men had not yet learned to distinguish psychology from philosophy. The psychologist wants to know what happens when Mrs. Jones or Johnny

Smith generalizes, or forms a concept. The philosopher wants to know what Mrs. Jones is thinking *about* when she forms a concept. There must, he says, be *something* that is general in the world, a "Universal" or general thought would be out of step with the universe. It was to some extent because men were confused between the nature of the Universal in the world and the nature of people's thinking about it that the trouble began.

But a mere confusion would not have been enough to make people kill each other. What made the arguments so bitter and so long? Whenever you find human beings behaving in a way that seems irrational or wasteful, it is a good rule to look for the motive. This is the lesson taught by all great students of human nature, from the Romans on. Freud is the last to have stressed the point, and thereby he added a completely new chapter to the science of psychiatry.

What was the motive of these, to us, ridiculous and senseless quarrels about the Universal? Apparently there were different motives at different times. At one period it seems to have been a motive of which we have heard a good deal during the last thirty years, *the drive of the under-dog against the top-dog* (and, for that matter, of the top-dog against the under-dog). Some of the quarrels about the concept appear to have been only skirmishes of this age-long battle.

Consider for example the world at the time when feudalism was just beginning to break up. Men, human beings like yourself and myself, were pushing to escape from serfdom and the miseries it brought. One can imagine the following dialogue.

Reformer: "Are they not all men, with their universal manhood in common? How then should we treat them as animals?"

Feudal Lord (who has attended classes in philosophy): "Yes, they are all men. But the only thing they have in common with the rest of mankind is the name."

This is exactly the answer certain philosophers taught the Feudal Lord to make!

Thus, far from being a quarrel merely about words, as many people have claimed, the dispute about the nature of the Universal has touched the very fabric of society and the place of man in it. The argument was by no means entirely about the Universal, but, for a while at least, whether verminous, starved and diseased men and women should toil while their masters drank out of silver cups.

Since it concerned the nature of the universe, the dispute over the Universal was a philosophical dispute, and it thus touches psychology only indirectly. In this book we are interested rather in how individual minds work. What has experiment to tell us about the *psychological process of generalizing* in your mind and mine?

WORKING TO OBTAIN AND TO IMPROVE A CONCEPT

First of all, *a concept is learned. It has to be worked for.* One experiment shows us children learning the general rule that if the weights at each end of a lever are to balance, the weight times its distance from the fulcrum must be equal on each side. This is shown with different distances and

weights, until the children "get the idea." As in every other kind of learning and thinking, a skillful teacher can help the process enormously.

A concept may be *improved by working on it*. In an experiment similar to that with the Zobbles, where meaningless colored shapes with common characteristics were shown one after another, people gradually cut out such unnecessary mental processes as superfluous imagery. Finally, after long practice, they developed the most economical concept, that is, the most economical way of dealing (mentally) with these different objects. Here, as in so many cases, learning is a matter of getting greater and greater economy into one's life. The economy comes both as one acquires the concept, which is a handle by which we deal with a number of objects, and also as one uses it. You learn it by dropping unnecessary processes, and you use it more easily.

As in every other kind of learning, *trial and error* is always found. Experiment shows people making mistakes in their concepts, setting up false generalizations, and then correcting them as experience shows where their mistake lies. Sometimes mistakes are not corrected. Then you get that frequent and dangerous thing, the false generalization.

There is a story of a young traveler in Normandy who stopped overnight at a wayside inn. It so happened that food had run short, and he was served by a red-headed waitress with the inevitable *potage* (soup with bread soaked in it), a bottle of good wine, and nothing else.

"The country people," he wrote home to his mother, "live on soggy soup and wine. The women are red-haired."

FALSE GENERALIZATION AND ITS DANGERS

False, or too hasty generalization may become a formidable thing. As a boy I lived on the south coast of England where the memory of hundreds of years of fighting the French still remained. "A Frenchman" was to us "a dirty Frenchman." He was a person who inevitably ran away when an English soldier appeared, and was in general a miserable, puny little fellow. When I was taken to France I was completely bowled over to see an enormous, fair Frenchman on the pier at Boulogne catching the hawser and apparently pulling the ship to land. Appearances were deceptive, but nevertheless my concept needed correcting.

Such false generalizations, "stereotypes," as they have been called by Walter Lippmann, may be very destructive. "Damn Yankee," it is said, became one word to certain Southerners in the United States. "Dirty Wop," "dirty Jew," have done immeasurable harm. "Shifty Greek" (*Mendax Graecus*) is two thousand years old, "Shiftless Irish" two hundred.

Lippmann points out that it is not generalization that does the harm, but false generalization, which often comes from trivial reasons. In an experiment by Dr. Rice, people were shown nine photographs from a daily paper, and asked to say which was a bootlegger, which a Soviet Envoy, which a labor leader, a United States Senator, and so on. It so happened that the Soviet Envoy was wearing a wing collar, and had a Van Dyke beard. He was thought to

be a Senator by 59 people, a Soviet Envoy by 9! Nobody thought he was a labor leader. The (alleged) bootlegger had a heavy overcoat with upturned collar, a cap, and a cigar firmly gripped between his teeth. He had the largest number of correct guesses!

Thus Generalization, together with *naming*, which with us human beings usually goes with it, is a powerful weapon, which can be used to destroy. It will be so used unless care is taken to correct inevitable errors.

These three psychological facts about concept formation, that a concept is learned, that it may be improved, and must be corrected, are illustrated many times over in scientific history.

GENERALIZATION MUST BE MOTIVATED

Generalization and abstraction are *motivated*, like other learning. If a person is shown rows of colored letters and asked to report the *color* of the top row or of the diagonal, for example, he can generally do so. If he is asked to say how many letters were exposed, he will often make mistakes about the color. In one experiment over 14 per cent of wrong colors were thus given by one person, nearly 9 per cent by another. Only 14 to 35 per cent of colors were given correctly when people were motivated towards a different abstraction. The eminent psychologist, Külpe, who first made these experiments, claimed that the more difficult a task is to which we are motivated, the more completely the background is blotted out.

If this is so (it has been confirmed by some and denied by others) it provides a long waited excuse for those husbands who forget to post a letter, and those scientists who leave their gloves in the laboratory.

Archimedes, who has already been mentioned as the first scientific detective, is said to have come to his death in what is often called a fit of abstraction. In the manner of the time, he was working out a problem of geometry by tracing a diagram in sand. It so happened that Syracuse, his home town, had just been captured by the Romans. A Roman soldier found the old man tracing those queer patterns, spoke to him and received no answer. For a Roman legionary in a captured city there was only one thing to do, and he did it. Thus died one of the greatest scientists of ancient times, of a too highly motivated abstraction! If the story is true, Archimedes was doing in an extreme form what Külpe's subjects did when they "blotted out" parts of what was shown them.

People adopt hypotheses in generalization, and motivate themselves accordingly. Thus subjects in the laboratory were asked to obtain a general idea of a group of colored shapes so that they could later give a definition. The figures were shown in succession. People would often begin to notice a special feature, and then give themselves the task of observing it whenever it appeared. They had adopted the hypothesis that this feature had something to do with the concept they were trying to form. The motive has, so to speak, subdivided itself, so that it becomes in part a motive to test the hypothesis.

A friend tells me: "I rented a garage which was difficult to get into especially when there was snow on the ground.

You had to go down the alley and turn at exactly the correct angle at the right place. Otherwise you had to back, and got stuck in the snow. It seemed to me that if I drove to one of the posts on the fence and then cramped my wheel hard, I ought to get it. After a few tries, I found I was turning too sharply. So I set up a white mark in the garage and drove straight towards it as soon as I passed the post. I never had any difficulty after that."

This is a particularly interesting case of practical reasoning. There is trial and error. There is action throughout, depending on perception. My friend, a scientist, made the hypothesis that he should drive as far as the fence-post, and then turn hard. For a while he was part-motivated towards action which would try out this hypothesis. The hypothesis had to be altered when it did not work. The aim of the driver was to find a rule, or general principle of action, which would save him trouble on a number of different occasions in the future. The rule was a simple one, but the method of finding a rule has been used in many complicated experiments on generalization.

This subdivision of the motive comes out in Professor Maier's *Rules for Reasoning*, the first of which says: *Locate a difficulty, and try to overcome it.* Maier was of course dealing with methods of solving all sorts of problems, not with generalization alone, but his rule applies also to the special problem of generalization.

GENERALIZATION AND INSTRUCTION

Should a child or an adult who is learning something be required to discover his own rules or generalizations, or

does it save time for an instructor or older person to tell him the rule first? Should young people be told what to do, or left to find out for themselves?

Experiment is by no means finished here; but what we have suggests something as follows. *When a rule can be put into words, instruction does seem to help.* Two experimenters tried this out in a game where counters had to be moved from one peg to another in certain ways. Verbal instruction helped, but a *demonstration did not.* Other experiments seem to show the same thing.* Although experiment has not yet said the last word, this principle seems to be clear, though one should always remember that it is sometimes not possible to make a rule that will go into words.

This means that example is not always better than precept. At least, it seems probable that example backed up by precept is better than example alone. One psychologist did however find that people who discovered their own rules remembered them better.

IN DEFENSE OF THE PLATITUDE

This is of course to some extent a defense of the platitude, and it is time that somebody did defend it. Shakespeare was from thirty-five to forty when he wrote *Hamlet.* You remember the silly old man Polonius who, when the young men were going to college, told them:

> "Neither a borrower nor a lender be;
> For loan oft loses both itself and friend."

* Ewert and Lambert, 1932; Hull; Sullivan.

The platitude is often a valuable thing for young people, although they do not like it. I did not like it myself. If a young man is told not to borrow or lend, because it will cause trouble later, he is apt to be annoyed, because many young men are borrowing and lending all the time! He doesn't know yet how valuable his friends are, and he is willing to take a chance. And in any case, most young men feel that they can break the rules with impunity!

The man who talks platitudes is regarded as a bore, because he often tells us what we know already, and don't want to be reminded of! A whole generation of adults have preferred a deaf ear to the ancestral voices prophesying war. Recently a chief of police advised people to listen to the back seat driver who is, generally, nearly as exasperating as the man talking platitudes, and for the same reason. If Shakespeare had been ten years older, Polonius might well have been shown as a wise old man.

METHODS OF GENERALIZING

What methods do we use when we generalize? Experiment is unanimous on one point. *One person may use one method, another another.* A child may use one method, an adult a different one. For example, negative instances, that is cases not falling under the rule or the concept, seem to help some people and not others. Some even find them a hindrance. That is, some people might do the Zobble exercise just as well without being shown the false Zobbles at all. Some people use more images than others, and use them in different ways. Not only does one person vary

from another in his methods of generalizing, but the same person may employ different methods on the same problem on different days, or even on the same day! The only thing that experiment can as yet say for certain about the methods of generalization is that they differ! It shows how psychology itself, which studies the way in which individual people think, differs from logic, which is independent of any one thinker. There is no variation in the logic of one man's conclusion and another's. There may be an immense difference in the way the two reach the conclusion.

And finally we are left with the great question which you will have been expecting long before this—

WHAT "IS" A CONCEPT?

This is part of the question which caused so much wrangling in the middle ages. For that reason it seems worth while to take a page or two to show the kind of answer that I believe most modern psychologists would give if they were asked.

Well, as we saw by example at the very beginning of this book, science now prefers not to answer a question beginning with "What is?" She prefers to phrase the question differently and to ask, How does the concept work, and what does it do? It was really the attempt to define the concept in terms of what it is, rather than what it does, that caused much of the early trouble and confusion. When for example people thought in terms of "ideas," they naturally defined a concept as a general idea. Then the philosophers got busy on the general idea, and soon showed that it

wouldn't work. An idea of a man must depict some particular man, short or tall, white-skinned or black-skinned. An idea of a triangle must have some particular shape, size and color.* The psychologist found himself in the same difficulty when he began to talk of the general image. A general image was not found to be necessarily different from a particular one. For instance, after an extended series of experiments on five people, lasting over a year, Miss Fisher said that "There exists no essential difference between the two kinds of imagery" (that is, between general and particular images).

If a concept is not a general image or a general idea, what is it? There seemed to be no answer. In fact there probably is no answer, because this is apparently one of those questions which is wrongly asked.

Once again the physical scientist cannot tell you what electricity is, but he can tell you in great detail what it does, and what he does to measure that. In this way he cuts himself loose from many meaningless verbal disputes of the past.

RESTATING THE QUESTION

What then does a concept *do?* In order to answer the question, we have to look at what happens. Human beings, in common with all other organisms, live in a world which is ceaselessly changing. The weather changes from day to day and so do the people we meet, the food we eat, our

* My friend Dr. H. M. Estall feels that I have been a little summary with the philosopher at this point.

bank balances, the problems we encounter in our daily business. If you drive a car, you never meet exactly the same traffic situation twice. If you are accustomed to live much in hotels, the arrangement of your rooms will differ from day to day. If you play golf or tennis, there is change of situation from game to game and from instant to instant in the same game. From this point of view, the world is confusion. Chaos is still with us. Creation has not yet occurred.

Yet we know that beneath this chaos there is at least *some* uniformity. People have *something* in common. They all breathe, eat, and cry out when they hit their thumb with a hammer. Hotel rooms have beds that are two or three feet off the floor, not tilted against the wash basins. Even the most eccentric of human beings, the man who is driving the other car, drives it in contact with the road, and not six inches off the ground.

The human being (that is, you and I) is able to discern the similarities in the constantly changing world in which he lives. Otherwise he could not live at all. *It is through this power to detect similarities in the endless flux of the environment that he is able to profit from his experience.* For experience helps us through the similarity of the changing past with the changing present.

THE CONCEPT INVOLVES ACTION

If you wish you may then define a concept as the *psychological process by which we perceive and react to similarities in the changing environment.*

You react to different Zobbles by attaching the same name to them. You react to the Buick that is rushing into the highway without stopping by *putting on your brakes*, although the last car that nearly killed you was an Austin speeding at a different intersection. You *turn* the hot water tap in your hotel although it has three prongs, while the tap in yesterday's hotel had four. Unless you had the ability to *discern and react to* these similarities in your daily environment, at the same time neglecting the irrelevant differences, you could not live your life. Nor could the lion even roar after his prey if he insisted on waiting until yesterday's conditions exactly repeated themselves. For nature never repeats herself, on the surface at least; her repetitions are hidden where he who runs must read them, or else fall down.

Of course, this takes a good deal of the glamour from the concept. I suppose early thinkers who believed that magnetism was a universal fluid would say that the modern physicist has taken the romance out of magnetism. Yet the modern way works, and can be put to work. The old way was interesting but useless.

WHY WE USE MANY METHODS TO GENERALIZE

All this means that when a person generalizes, he will use whatever resources he has and which he finds useful. Nothing can be more general than a proposition of geometry. Yet when I lately asked a young mathematician how he does these problems, he told me:

"I make a mental picture of the figure on the wall. It is in a greenish-gray color, and I can alter it as I want. It is much less trouble than drawing the figure." He uses a particular image to improve a general proposition.

A chemist tells me:

"I *see* the (chemical) equation in my mind, and sometimes have to alter it if I get it wrong." A chemical formula is a very general statement which applies to an infinite number of particular situations. The chemist, too, uses a particular image of a formula to illustrate his general conclusion.

Most people, again, use words in their generalizing, and that is what gave rise to the notion that the concept *is* a word. But the concept is none of these things, neither visual nor any other kind of image, nor words, spoken aloud or silent. It is the psychologist's name for the whole process by which we deal with things which differ but are similar. The thinker may use images, visual or any other kind, words, spoken, silent or written, or any other tool of thought he may possess.

"What do you do when you see the enemy coming on a dark night?" asked the old lady of the Cockney commando.

"Lydy, I 'it 'im any blinking way I can."

That is the way the concept works also.

IS GENERALIZING A SPECIAL KIND OF LEARNING?

There is just one other question that may have been puzzling you. Let me put it for you.

If a concept has to be learned, and is simply our way of dealing with a number of different but similar things, what is the difference between learning a concept and any other kind of learning, such as learning to play bridge or to speak a language? Is there a special kind of learning, which we call concept formation?

Concept formation is not a special process. When we learn, we are forming concepts. When we are forming concepts we are learning.

Once more, let us interview the humble rat. Dr. Lashley trained four rats to jump to the *larger* of two circles. He did this by always feeding them when they jumped to the larger, and letting them fall into a cloth apron when they jumped to the smaller. This took something under a hundred trials. He then placed them in front of a small circle and a large triangle. They still chose the *larger* area (the triangle) even though the shape was different. That is, they had abstracted and generalized, and learned to give the *same* response to any *larger* area. This was clearly shown from two facts. After two hundred trials with the larger triangle and smaller circle, they were completely confused when shown a triangle and circle of equal areas. After this they always chose the larger of the two figures, whether it was a circle or a triangle.

This was a really remarkable experiment. It showed that the rat learned in general terms. He always jumped to "largeness," irrespective of the different figures in which it was found.

This conclusion, that all learning is general, and involves abstraction, or neglect of meaningless differences, is really obvious if you look at the facts. Some of them have already

been given. Remember that Nature-on-the-street is always changing. That was what old Plato quarreled with her about. Nature changes, but what you learn still holds good.

In the laboratory, when we try to keep conditions constant as in the animal or human maze, we speak of a "learning" experiment. When we deliberately vary conditions, as in Lashley's experiment with the rats, we call it "generalization." But in each experiment there is neglect of varying details, and learning that applies in spite of the variations. Thus it is not surprising to find, as several investigators have done, that ability to generalize increases as intelligence increases; for we know that greater intelligence carries greater ability to learn.

So that the mysterious concept has vanished into the mystery of learning. *Abit in mysterium*, said the Romans—it disappears into a mystery. And so it does! And once again the scientist joins hands with the philosopher. For the gentle don Bradley, in his armchair at Oxford, made the same point as Lashley, about the time Lashley was getting born! Though Bradley would have been completely scandalized if he had been told that the baby would grow into a scientist who would prove him true by making rats jump!

THE CONCEPT AND MODERN EDUCATION

This long chapter must soon end. But before it does, I must point out once again that what seems just an argu-

ment between psychologists really has immense practical importance.

Remember that *all learning is generalizing, all generalizing is learning.* What then of children's learning at school? A good many people are complaining about the education of today. The other day, a man in a hotel lobby (frankly, I find him a bit of a bore!) let off something like this to me:

"It is true that these youngsters know a lot of facts, but they are not educated all the same. They can make ninety per cent on a true-false examination about the history of their country, but the juvenile delinquency rate is rising. To put it mildly they are no better citizens than their parents were, in spite of everything we hear about modern methods of teaching. We are raising good technicians, not good men and women."

Whether or not all his facts were right, he had a point. Much of what is learned in the ordinary class room, where people should be learning how to live, often stays in the class room, until it finally escapes once and for all into an examination paper in another class room. Things are often different in the vocational training school. Much of what is learned of how to make a living stays with the pupil as he goes through life. The future housewife will not be likely to remember the exports of Peru. The future doctor will remember the functions of the liver.

Of course, you begin to know the answer. The doctor applies his knowledge, the housewife does not. General motivation also accounts for some of the difference. A person learning to be a plumber or a lawyer is better motivated to remember the details of his future job than are most of our children to become good citizens. But that is not all.

Children were told as an experiment to pay special attention to the neatness of their arithmetic. They did neater arithmetic, but their other lessons were not any neater. Other children were taught to be neat in arithmetic as part of being neat in their general life. The other lessons of these children became neater!

What are now called the humanities are on trial. The practical minded person says, as Herbert Spencer said long ago,

"Teach them something that will be of use when they get out into the world."

The champion of the humanities says:

"Teach them something that will make them better men and women."

Both are right. We need skilled technicians and also good citizens. But for the "humanities," literature, history, civics, by which we hope to make better people, the problem is to some extent one of generalization and of its motivation. Remember Külpe's experiment in which people remembered letters, because they were motivated to do so, and forgot colors. Children who are motivated to remember the date when the American Civil War ended, or when the tyrant King John died of a surfeit of lampreys, will do just that. Those who are motivated to be better people because of the sacrifices our forbears made in the cause of freedom, will become better people. The textbooks may be the same in each case. But the one child has been led to acquire a fact, the other to abstract a general principle of living. If the "humanities" are to survive in the intense competition of today, they must show that they do make better people. This means that people studying them must be motivated

towards the right generalizations.

The following rules come out of this long chapter on generalization.

(1) It is your concepts that give your thinking the power to deal with your ever-changing environment. Without them your world would be to you so completely different from day to day that you could probably not survive at all. They are the breath and pulse of your thought.

(2) When you acquire a concept, you do in a simple way what science has done. You gain power over an infinite number of differing things. You name. You can predict.

(3) You have to work to acquire your concepts and to improve them.

(4) Beware of the false concept, the hasty generalization, the "stereotype." It will do your thinking and your life much harm. It has unjustly damned whole peoples.

(5) Do not always scorn the platitude. It is sometimes a back seat driver that is worth listening to.

(6) When you learn anything, learn it in its fullest possible implications. If you are a plumber or a lawyer, making a good job of your work should not be left in the cellar or the office. It should carry over into your life as a man.

CONCLUSION

THE PLACE OF THINKING IN HUMAN LIFE

MODERN psychology sees the activity that we call thinking as an aspect of our struggle in the world about us. Man must go forward and conquer the world, or the world will conquer him. He has his desires, his motives, springing from his needs. These needs are of diverse nature, from the great primary necessities of food, drink and warmth, to the more complicated needs for self-assertion and acquisition, and the infinitely complex sexual need and the need for children. The needs differ in their origin and their urgency; but they all do much the same thing. They drive man forward to meet the world of things and of people. They use the patterns that nature or nurture has given him. They keep him restless in a restless world. He must go on until they are satisfied, and then, in many cases, the cycle begins again.

Sometimes in the satisfaction of his needs he comes immediately upon what he wants. Then there is no problem. A problem comes only when he is thwarted by circumstances. How to get what he wants, although people or things bar the way? It is here that he must stop, look and

think about his situation. When he thinks thus directedly, or reasons, he does everything that he can, and that will help him reach his goal. He is a talking creature, so that he may talk, to himself or to others. He is an imagining creature, so that he may make mental images. He is a moving creature, and has been since his earliest beginnings. So that above all he moves; and even when you cannot see him move, his muscles are restlessly working. He does all this through his nervous system, and organizes the whole through his own specially developed nervous structure, the cortex of his brain.

At times he seems to take a holiday from the harsh reality of circumstance. Then he lets his wishes run half wild, in phantasy. But so strong and pervasive is the net which circumstance has thrown about him that he can never wholly escape. Even the wildest of waking or sleeping dreams is couched in terms of some kind of reality. In phantasy or daydreaming we say that he is still thinking, but not directedly. The course of his thoughts is not tied down at every step by reality. He is not reasoning.

Experiment on reasoning presents immense difficulties, many of which have been overcome by ingenious men. As a result, the picture of what happens seems to have emerged in broad outline. It is this outline that the preceding pages have tried to sketch. There are many gaps which must be filled out. To fill them is perhaps the most important thing in the world. For again, it is directed thinking that has raised man from the cave, and it is possible that directed thinking will bring him back to it again.

The atomic bomb, the mist-carried virus that may yet

destroy us; the life-giving mold and the mercy-bringing aeroplane that have saved so many of us, are but by-products. We must learn to understand more fully their source, the thinking of reasoning man. We must learn it in the laboratory.

POSTSCRIPT FOR PSYCHOLOGISTS

I BELIEVE that like chemistry, physics and astronomy, psychology has grown up sufficiently to present the results of experiment in a form that is frankly intended to appeal to the non-technical reader. Acting on this belief, I have used in this small book whatever illustrations came to hand, literary, anecdotal or what not. The illustrations are intended to illustrate only; with one self-explanatory exception, I have never, for example, used an anecdote as the source of psychological information. Psychologists must, in fact, derive their explanatory illustrations from the way in which people behave in everyday life.

Acting on the above belief, I have given a popular presentation of some of the very considerable body of experimental work bearing on the thought processes. The experimental results have been presented in terms both of experience and behavior. The reason for this is largely historical. Most of the earlier work, and very competent some of it was, antedated Watson's revolution. My own preference is for description in terms of behavior where this is possible. But to have indulged it completely in this book would have meant omitting an important mass of good work. If I have been forced at times to speak in "mentalistic" terms, for example in the description of "mental" trial

and error, this was because adequate translation of this important body of work into more modern terminology has not yet been effected. The difficulty was most obtrusive in the account of language. Language is described as a tool of thought. More correctly, it should perhaps be said that there is evidence, in the work of Lashley and others, that there exist central processes prior to and common to whole groups of peripheral responses, and that language comes under this general rule, and so on. The latest and most hardheaded of behavioristic analysts of language, Dr. Morris, has recently stated that we cannot yet analyze even our everyday speech in terms of behavior. I have attempted a modestly operational definition of the Concept. But much of the experimental work is described not in terms which most experimental psychologists would prefer to use today, but in the terms used by the experimenter at the time. Admirers of Gordon Allport's persuasive and learned *Personality* may feel that I have done less than justice to that excellent work, particularly in the discussions of motivation. But to state just where I believe the evidence is for and just where it is against his doctrine of motivation would take one beyond the confines of a popular book. In any case, it is exactly this kind of discussion that the publishers tell me I must avoid. Others may feel that I have used the term "motive" where "set" should sometimes more properly stand. This usage, and other slightly irregular ones, it is again not the place of this book to justify.

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April 1947

SOME REFERENCES

This is of course not a complete bibliography. It includes a few books and articles to which for one reason or another I should like to make special reference. The reader who wishes a more complete account of some of the recent literature will find one in Donald Johnson's article in the *Psychological Bulletin* (41,4, April 1944).

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